MANUAL
OF
DAIRY CATTLE BREEDING

MANUAL
OF
DAIRY CATTLE BREEDING

BY

JOHN W. GOWEN, PH.D.

Maine Agricultural Experiment Station

BALTIMORE
THE WILLIAMS & WILKINS COMPANY
1925

Made in United States of America

PUBLISHED SEPTEMBER, 1925

COMPOSED AND PRINTED AT THE
WAVERLY PRESS
FOR
THE WILLIAMS & WILKINS COMPANY
BALTIMORE, MD., U. S. A.

CONTENTS

PREFACE

This manual is prepared as a laboratory text for students primarily interested in dairy cattle breeding. A good training is desirable in the elements of biology including courses in pure genetics, cytology, and the mathematics of statistics before commencing this work in the agricultural college. Desirable students need not be excluded from the course, however, if they lack courses in these subjects. It will simply mean that such students will have to do outside reading in such texts as T. H. Morgan, 1919, *Physical Basis of Heredity*, Lippincott Company, Philadelphia; T. H. Morgan, A. H. Sturtevant, H. J. Muller, and C. A. Bridges, 1915, *The Mechanism of Mendelian Heredity*, Henry Holt and Company, New York; Babcock and Clauson, 1918, *Genetics in Relation to Agriculture*, McGraw-Hill Book Company, New York; G. Udny Yule, 1919, fifth edition, *An Introduction to the Theory of Statistics*, Lippincott Company, Philadelphia.

The basis for the lecture course to accompany the laboratory course is found in the text, *Milk Secretion*, 1924 (Williams and Wilkins Company, Baltimore). The citations to reading in this text are indicated by the abbreviations *M. S.* The citations to other sources are indicated by rather complete references. No effort is made to give references to general genetic or physiological literature as it is believed that these courses are better given in the pure science sections of the University than in the Agricultural College proper.

It is fairly obvious in a course of this kind, necessarily limited for time, that the work had better be confined in general to one breed of dairy cattle. This breed may be changed from year to year indicating to the student that the results for the different breeds correspond quite closely in the principles involved. By following through this outline with dairy cattle the student will obtain an excellent foundation on which to study similar problems in other types of livestock, horses, sheep, swine, etc. A rather complete list of papers relating to cattle breeding is found in the bibliography.

CHAPTER I

Origin and Early History of Breeds of Dairy Cattle

It is important in any consideration of a breeding problem to have a firm grounding in the mode by which the breed originated. A review of the early history of the dairy breeds will reveal:

1. Origin of the parental stock.
2. Probable inbreeding which took place.
3. Chances for homozygous and heterozygous stock.
4. Breeding measures adopted which would be likely to influence color, type, milk yield, and butter-fat percentage.
5. Other points of importance to breeding problem.

Review history of formative period of the different breeds from this point of view. The opportunity is a good one for bringing out the judgment of the student in making a critical unbiassed review.

REFERENCES

Numerous sources of information will suggest themselves to the instructor.

Cole, L. J., and Jones, L. V. H. 1920. *The Occurrence of Red Calves in Black Breeds of Cattle*, Wisconsin Bulletin 313, for critical review of the Holstein-Friesian breed's origin. A review of this is given in Chapter I of *M. S.*

Youatt, William. *Stock Raising Manual*, brings out important points concerning the early breeder's ideals.

Wallace, Robert. 1907. *Farm Live Stock of Great Britain*, Edinburgh, gives a brief review of all the breed histories in so far as the British Isles influenced them.

Wilson, James. *The Evolution of British Cattle and the Fashioning of the Breeds.*

Sanders, J. 1887. *Breeds of Live Stock and the Principles of Heredity*, Chicago.

The early herd books of the breed associations and the information which may be obtained from these associations furnish other sources of data for the study of breed origin. Credit is to be given for all other sources of information which you are able to find. Write a 500-word paper on this subject for the breed chosen using as your guide the five points indicated above. Have the reference

to the original literature in clear standard form, name of author, date of publication, the title of article or book, place of publication, volume number, and pages. It might be advisable to have different students take different breeds. The reading and discussion of the best papers furnishes an excellent means of fixing this information.

CHAPTER II

Development of Registration as a Means of Isolating and Perpetuating Breeds

A large proportion of the data collected for Chapter I can also be used for this chapter. The problem should be considered from the viewpoint of how registration has influenced the breeding problems of dairy cattle. Data should be included to show when the breed organization took place; what breeds, if any, were used to form the modern breed; under what conditions cattle were admitted to registry; etc. Define the difference between registered, purebred, grade, and scrub members of the breed. Write a 500-word paper on one of the dairy breeds. The best papers may be read before the class and discussed in the laboratory period.

REFERENCES

Besides those indicated in chapter (I) we might add Col. Le Conteur, Col. C. P. Cornu, and Thornton, 1845, 1851, 1853, 1859, some references in *Journal Royal Agricultural Society of England*, volumes V, XII, XVII, XX.

Housman, W. *Cattle Breeds and Management*, Vinton & Co., London.

The early breed histories as contained in the herd books and such modern standard tests as:

Eckles, C. H., and Warren, G. F. 1916. *Dairy Farming*, Macmillan & Co.

Plumb, Charles Sumner. Rev. ed., 1920. *Types and Breeds of Farm Animals*, Ginn & Co.

The student in writing his paper should make an effort to look up and tabulate a complete literature list.

CHAPTER III

Breeds of Dairy Cattle and Mode of Recording in Each Breed

List the breeds normally classified as dairy cattle with the names and addresses of their secretaries and the offices where the registration takes place. Visit one of these offices and see how the business of registration is carried on, if this can be done. Make out proper registration papers for a calf and an adult bull or cow. Make out proper transfer papers.

Review conditions for registration both past and present. How are imported cows registered? Write a 250-word paper comparing methods of registration in the different breeds. Answers to questions like the following should be noted: How do unregistered animals on the Jersey Isle differ from those in this country and what are the differences in mode of registration?

REFERENCE

U. S. Dept. Agr. Farmers' Bulletin 106, *Breeds of Dairy Cattle.*

Blanks for registration and transfer of cattle are found in the text, pages 14–29. The history of changes in registration may be obtained from the herd book or from the breed associations. Point out any differences in the form of registration of transfer as adopted by the different breeds.

File with the Secretary

THIS SPACE FOR SECRETARY'S USE

Official No.....Cash Book Folio

Received.....No. .....

APPLICATION FOR REGISTRY

Indicate the fee sent by checking the proper square

MEMBERS' FEES		NON-MEMBERS' FEES	
Females, $1.00 ☐	Over 1 year old, $2.00 ☐	Females, $2.00 ☐	Over 1 year old, $4.00 ☐
Males, $2.00 ☐	Over 1 year old, $4.00 ☐	Males, $4.00 ☐	Over 1 year old, $8.00 ☐

Write plainly each word and figure, in unmistakable characters

Sex..... Ear-Tag No.....

Name.....
(No name should contain over 30 letters)

Date of Birth .....Color.....
(Month, day, year)

Name of Sire .....

..... No.....H.B

Name of Dam.....

..... No..... .....H.B

Signature of Owner of Dam when bred .....

Post-Office Address.....

Signature of Owner of Dam at time Calf was dropped.....

Post-Office Address.....

Signature of Applicant for Registry .....

Post-Office Address .....

CERTIFICATE OF SERVICE OF DAM

This relates to the service which produced the calf about to be recorded. If the dam was pasture bred, do not fill out the form below, but attach special form for pasture service only.

This is to Certify that the Bull .....

..... No.....H.B.

served the Cow .....

. ..... No.....H.B.

on.....192.....

(Month, day, year)

Signature of Owner of Bull.....

Post-Office Address.....

Attention is called to the following By-Law:

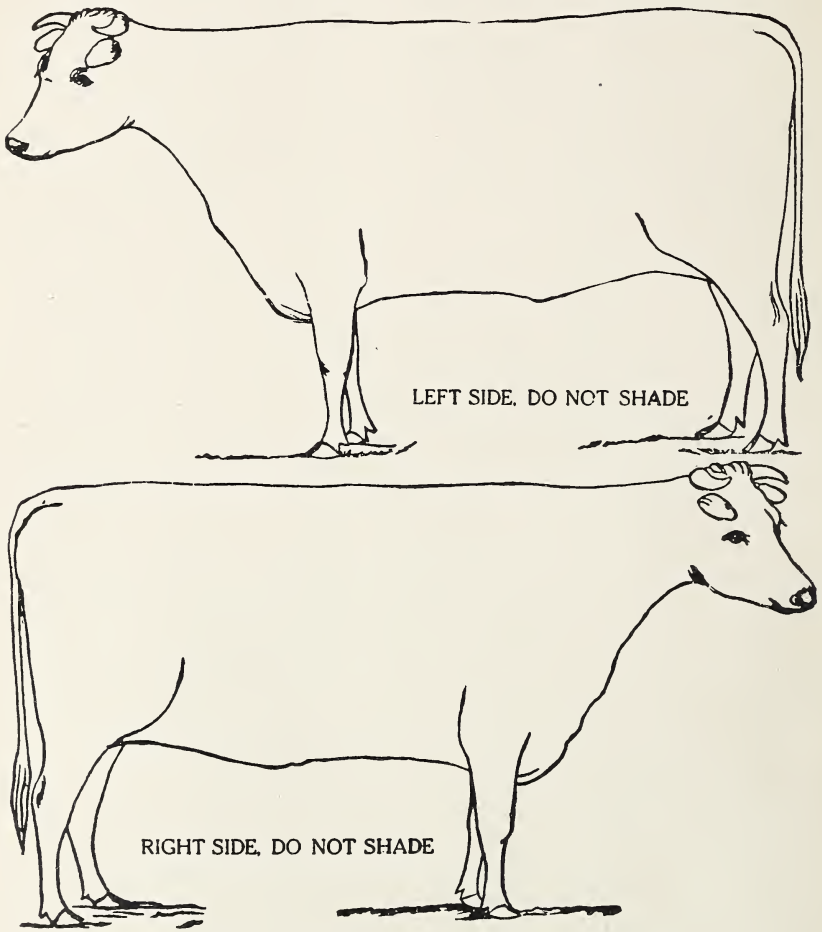
Every application for the registry of an animal in the Herd-Book shall be taken as the guarantee of the owner that the animal is purebred, and that all matters stated in the application are true.

Examined..... Checked..... Colors..... Verified. ..... Mailed.....

IMPORTANT: The certificate of comparison (at bottom of sheet) must be dated and signed by someone who has compared this sketch with the animal to be recorded and knows it is correct. The certificate of registry CANNOT be issued until this has been done. All signatures must be made with ink.

BOTH OUTLINES TO BE FINISHED WITH INK

Name of Dam of Animal Sketched.....



CERTIFICATE OF COMPARISON

I have compared these diagrams with the animal to be recorded, and find them to be correct.

Signature.....Date.....

Within ten days of date of sale
File with the Secretary

THIS SPACE FOR SECRETARY'S USE

No..... Folio.....

Received .....

APPLICATION FOR TRANSFER

Members' Fees, $1.50

After three months from date of sale, $3.00

Non-Members' Fees, $3.00

After three months from date of sale, $6.00

Seller's Signature..... P. O. Address.....

Buyer's Name..... P. O. Address.....

Sex of Animal..... No. .....in Herd-Book. Ear-Tag No.....

Name of Animal .....

Date of Sale.....19..... Date of Delivery, if later than date of Sale.....19.....

If the animal transferred is a female and was served previous to delivery, this service certificate must be filled in and signed. If not served, write the words "Not served" thereon.

CERTIFICATE OF SERVICE

This is to certify that the bull

..... No.....

served the Cow

..... No.....

Date of
Service.....19.....

Signature of
Owner of Bull.....

Post-Office Address.....

19

NOTICE

It is forbidden by the rules of the Association to transfer to any other person than the actual purchaser, and sellers doing so lay themselves liable to the penalties imposed by the Constitution and By-Laws.

In accepting or recording this application for transfer the CLUB does not guarantee the accuracy of the certificate of service indorsed thereon and is in no manner committed to the registration of the calf that may result from such service.

In case the words "Not bred in my possession" are used in place of above certificate, the owner should sign his name after writing those words and give the date.

INSTRUCTIONS

By carefully following these instructions and verifying your applications before filing them with the Secretary, you will save yourself much time and annoyance.

Applications must always be made on the blanks, which are furnished by the Secretary on request, free of charge.

Write all names, numbers and addresses distinctly in ink. If written in pencil they must be returned to you to be rewritten in ink.

Always give all the initials or, if possible, give names in full of both seller and buyer.

The complete post-office address, including street number, or route and box number, should be given on every application.

The dates of sale and service must be accurate and complete, showing month, day, and year.

The certificate of service, showing whether or not the female was in calf when sold, must be filled in and signed. If the animal had not been served, write the words "Not served" thereon. If this is omitted the application must be returned to you.

Do not tear off the certificate of service if the animal has not been served, nor in any way cut or mutilate the blanks.

Breeders are required under the By-Laws to keep a Herd Register.

Do not erase or try to correct errors made in filling out a blank; use a new blank.

Blanks should be very carefully written and neatly folded, as they are part of a permanent record in the Secretary's office.

Before mailing verify each application from your Private Herd Register.

Applications must be personally signed by the seller, unless a power of attorney has been given, authorizing the person who actually signs the blank to make such signature.

Postage stamps cannot be accepted in payment of fees under any circumstances.

All errors in spelling names, and in dates and addresses upon certificates which have been issued by the Secretary, will be cheerfully corrected, free of charge, but most of such mistakes can be avoided if proper care is used in making out the original application.

Always compare the color markings shown on the certificate of registry with the animal named in this transfer, to be sure the right animal has been delivered.

Animals must be transferred to owners before their offspring can be registered. (All ownerships must show upon the records.)

Whenever an animal is sold the seller shall furnish an application for transfer of the animal upon the records of the Association, written upon the form furnished by the Association.

In case of the neglect or unreasonable refusal of the seller to give such application for a transfer, a record of the transfer may be made by the Secretary, upon approval of the Executive Committee. on evidence of the sale and delivery and full payment for the animal.

A record of all transfers of ownership of registered animals must be made upon the records of the corporation, and it shall be the duty of the seller of any animal to file with the Secretary the necessary application for such transfer within ten days after the date of sale. Date of sale shall be held to be the date of delivery of possession of the animal. Failure to comply with this provision may be deemed an infraction of the By-Laws, and the offender will be subject to such penalty as is within the power of the corporation.

File with the Secretary

THIS SPACE FOR SECRETARY'S USE

Official No.....Cash Book Folio

Received.....No. .....

APPLICATION FOR REGISTRY

Indicate the fee sent by checking the proper square

MEMBERS' FEES		NON-MEMBERS' FEES	
Females, $1.00 ☐	Over 1 year old, $2.00 ☐	Females, $2.00 ☐	Over 1 year old, $4.00 ☐
Males, $2.00 ☐	Over 1 year old, $4.00 ☐	Males, $4.00 ☐	Over 1 year old, $8.00 ☐

Write plainly each word and figure, in unmistakable characters

Sex..... Ear-Tag No.....

Name.....

(No name should contain over 30 letters)

Date of Birth .....Color.....

(Month, day, year)

Name of Sire .....

..... No.....H.B

Name of Dam.....

..... No.....H.B

Signature of Owner of Dam when bred .....

Post-Office Address.....

Signature of Owner of Dam at time Calf was dropped.....

Post-Office Address.....

Signature of Applicant for Registry .....

Post-Office Address .....

CERTIFICATE OF SERVICE OF DAM

This relates to the service which produced the calf about to be recorded. If the dam was pasture bred, do not fill out the form below, but attach special form for pasture service only.

This is to Certify that the Bull .....

..... No.....H.B.

served the Cow .....

.. .. No.....H.B.

on.....192.....
(Month, day, year)

Signature of Owner of Bull.....

Post-Office Address.....

Attention is called to the following By-Law:

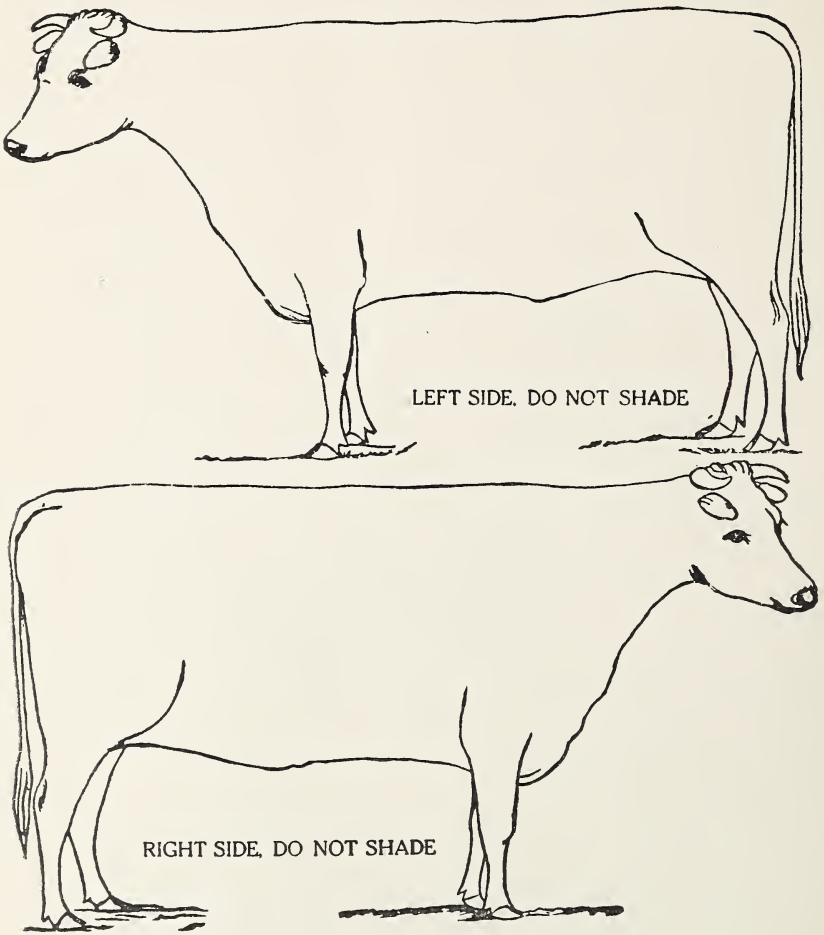
Every application for the registry of an animal in the Herd-Book shall be taken as the guarantee of the owner that the animal is purebred, and that all matters stated in the application are true.

Examined..... Checked..... Colors..... Verified..... Mailed.....

IMPORTANT: The certificate of comparison (at bottom of sheet) must be dated and signed by someone who has compared this sketch with the animal to be recorded and knows it is correct. The certificate of registry CANNOT be issued until this has been done. All signatures must be made with ink.

BOTH OUTLINES TO BE FINISHED WITH INK

Name of Dam of Animal Sketched.....



CERTIFICATE OF COMPARISON

I have compared these diagrams with the animal to be recorded, and find them to be correct.

Signature.....Date.....

Within ten days of date of sale
File with the Secretary

THIS SPACE FOR SECRETARY'S USE

No..... Folio.....

Received .....

APPLICATION FOR TRANSFER

Members' Fees, $1.50

After three months from date of sale, $3.00

Non-Members' Fees, $3.00

After three months from date of sale, $6.00

Seller's Signature..... P. O. Address.....

Buyer's Name..... P. O. Address.....

Sex of Animal.....No. .....in Herd-Book. Ear-Tag No.....

Name of Animal .....

Date of Sale.....19..... Date of Delivery, if later than date of Sale.....19.....

If the animal transferred is a female and was served previous to delivery, this service certificate must be filled in and signed. If not served, write the words "Not served" thereon.

CERTIFICATE OF SERVICE

This is to certify that the bull

..... No.....

served the Cow

..... No.....

Date of
Service..... 19.....

Signature of
Owner of Bull.....

Post-Office Address.....

NOTICE

It is forbidden by the rules of the Association to transfer to any other person than the actual purchaser, and sellers doing so lay themselves liable to the penalties imposed by the Constitution and By-Laws.

In accepting or recording this application for transfer the CLUB does not guarantee the accuracy of the certificate of service indorsed thereon and is in no manner committed to the registration of the calf that may result from such service.

In case the words "Not bred in my possession" are used in place of above certificate, the owner should sign his name after writing those words and give the date.

INSTRUCTIONS

By carefully following these instructions and verifying your applications before filing them with the Secretary, you will save yourself much time and annoyance.

Applications must always be made on the blanks, which are furnished by the Secretary on request, free of charge.

Write all names, numbers and addresses distinctly in ink. If written in pencil they must be returned to you to be rewritten in ink.

Always give all the initials or, if possible, give names in full of both seller and buyer.

The complete post-office address, including street number, or route and box number, should be given on every application.

The dates of sale and service must be accurate and complete, showing month, day, and year.

The certificate of service, showing whether or not the female was in calf when sold, must be filled in and signed. If the animal had not been served, write the words "Not served" thereon. If this is omitted the application must be returned to you.

Do not tear off the certificate of service if the animal has not been served, nor in any way cut or mutilate the blanks.

Breeders are required under the By-Laws to keep a Herd Register.

Do not erase or try to correct errors made in filling out a blank; use a new blank.

Blanks should be very carefully written and neatly folded, as they are part of a permanent record in the Secretary's office.

Before mailing verify each application from your Private Herd Register.

Applications must be personally signed by the seller, unless a power of attorney has been given, authorizing the person who actually signs the blank to make such signature.

Postage stamps cannot be accepted in payment of fees under any circumstances.

All errors in spelling names, and in dates and addresses upon certificates which have been issued by the Secretary, will be cheerfully corrected, free of charge, but most of such mistakes can be avoided if proper care is used in making out the original application.

Always compare the color markings shown on the certificate of registry with the animal named in this transfer, to be sure the right animal has been delivered.

Animals must be transferred to owners before their offspring can be registered. (All ownerships must show upon the records.)

Whenever an animal is sold the seller shall furnish an application for transfer of the animal upon the records of the Association, written upon the form furnished by the Association.

In case of the neglect or unreasonable refusal of the seller to give such application for a transfer, a record of the transfer may be made by the Secretary, upon approval of the Executive Committee, on evidence of the sale and delivery and full payment for the animal.

A record of all transfers of ownership of registered animals must be made upon the records of the corporation, and it shall be the duty of the seller of any animal to file with the Secretary the necessary application for such transfer within ten days after the date of sale. Date of sale shall be held to be the date of delivery of possession of the animal. Failure to comply with this provision may be deemed an infraction of the By-Laws, and the offender will be subject to such penalty as is within the power of the corporation.

CHAPTER IV

Development of Productivity Registers

The basis of any constructive breeding program consists of a register showing the exact breeding of an animal and a register showing the productivity of the animal, its ancestors, and offspring. Of the published data, the advanced registry records of the different breed associations are the chief sources of information here in the United States. The cow testing associations also obtain records but these are not in an easily available form for inheritance work. In Scotland, Ayrshire records are recorded by the Cattle Milk Records Committee. In Denmark records similar to our cow testing records are obtained.

Each student may be assigned a breed of dairy cattle in the United States to look up its advanced registry system, how it commenced, by whom it was commenced, and what the requirements for entry were. What changes have been made in these requirements since the beginning of the recording of these productivity records? In view of the history of the advanced registries write a paper on the suitability of the records for inheritance work and for the use of the breeder as a guide to his breeding operations. Note especially the possible influence of the requirement for entry, see *M. S.*, chapter VIII.

Let the student hunt up his own reference material in such sources as the Experiment Station Record.

Supplementary exercise: Examine the rules of the different cow testing associations in this country and abroad for their adequacy in furnishing facts on which to base the following:

1. Selecting cattle for breeding.
2. Ease of pedigreeing animals.
3. When the pedigrees of an animal are made, the ease with which the production records of each ancestor may be added to the pedigree.
4. Determining a cow's own production and her probable subsequent production. See also *M. S.*, Chapter VI.

A lecture on the use of the herd book and advanced register in tracing a pedigree and searching out the records of different animals may well be included. It is suggested that this be a demonstration with a chance for the greatest freedom in asking questions by the class.

CHAPTER V

Tracing a Pedigree

At the bottom of most practical breeding operations is the pedigree. The successful breeder must know how to trace a pedigree correctly and to interpret it properly after it is traced. If the pedigree is so important to the breeder it is equally important to the student of cattle breeding.

In view of what is to follow the whole class should trace pedigrees of animals in the same breed. It is suggested that each student trace for four complete generations the pedigrees of four animals, two bulls and two cows. One bull and one cow to be noted Advanced Registry animals, the other bull and cow to be chosen entirely at random[1] but to have neither Advanced Registry offspring nor records of their own.

Each student is furnished with pedigree blanks in which he will fill in the pedigrees of the animals chosen. These are found on

[1] A good way to choose the animals at random is to place in a hat 10 slips of paper numbered from 0 to 9 and have the student draw from the hat. Suppose the student's first draw is 1, or the number in the 100,000 column would be 1. The student's second draw gives the 10,000 number, say the draw is 5; the third the 1000 number, say, is 9; the fourth, the 100, let us say is 2: the fifth, the tens, is 3; the sixth, the units, is 4. The number chosen is, consequently, 159,234, which would be the number of the animal that the student is to pedigree, providing of course it has no Advanced Registry record. The slip is returned to the hat at each draw so there are always 10 slips from which to draw. In case the animal drawn has Advanced Registry records choose the next nearest animal which has no such records. The bulls and cows that a given student pedigrees should if possible be chosen from the same volume of the herd book so as to eliminate the influence of more cows than bulls being recorded. Otherwise the animals pedigreed will be many years apart in dates of birth and consequently the younger one will have less chance of having the same ancestors in a given generation than the animal of early birth. It is also important to have the random sample numbers approximately the same as those of the Advanced Registry. This may be done by allowing the two Advanced Registry animals already pedigreed to determine the first three places and drawing as above for the hundreds, tens, and units.

pages 35–40. A specimen pedigree of King Hengerveld Aaggie Fayne 56635, a Holstein-Friesian bull of merit is given on page 34. While the pedigrees indicated are for four generations, the system may be used for any number of generations by using the "Sheet Number" at the upper left and the "Go to sheet" at right of the pedigree blanks.

Sheet No.						Go to Sheet
No. 56635 King Hengerveld Aaggie Fayne ♂	♂	No. 36168 ♂ King Segis	No. 29830 ♂ Mercedes Julip's Pietertje's Paul	No. 21724 ♂ Paul DeKol		
				No. 39480 ♀ Mercedes Julip's Pietertje		
			No. 55163 ♀ A & G Inka McKinley	No. 23378 ♂ Billy McKinley		
				No. 36617 ♀ Segis Inka		
	No. 46767 King Fayne Segis	No. 68828 ♀ Grace Fayne 2d's Homestead	No. 28400 ♂ Homestead Jr. DeKol	No. 24762 ♂ Paul DeKol Jr.		
				No. 46490 ♀ Homestead Heroine DeKol		
			No. 44124 ♀ Grace Fayne 2d	No. 19856 ♂ Aaltje Salo 3d's Tritomia Neth.		
				No. 37840 ♀ Grace Fayne		
	♀	No. 23102 ♂ Hengerveld DeKol	No. 21366 ♂ DeKol 2d's Butter Boy	No. 19056 ♂ Sir Abbekerk		
				No. 734 ♀ DeKol 2d		
			No. 29237 ♀ Magadora	No. 7825 ♂ Milla's Pietertje Netherland		
				No. 13106 ♀ Netherland Hengerveld		
	No. 88652 Bloomingdale Hengerveld Aaggie	No. 70941 ♀ Susie Aaggie Rue	No. 26939 ♂ Johanna Rue 3d's Lad	No. 23971 ♂ Sarcastic Lad		
				No. 42167 ♀ Johanna Rue 3d		
			No. 39782 ♀ Susie DeKol's Aaggie Wayne DeKol	No. 20928 ♂ Aaggie Wayne 4th's Paul DeKol		
				No. 33688 ♀ Susie DeKol		

Sheet No.	♂	No.	♂	No.	♂	No.	♂	Go to Sheet
						No.	♀	
				No.	♀	No.	♂	
						No.	♀	
		No.	♀	No.	♂	No.	♂	
						No.	♀	
				No.	♀	No.	♂	
						No.	♀	
Sex	No.							
	♀	No.	♂	No.	♂	No.	♂	
						No.	♀	
				No.	♀	No.	♂	
						No.	♀	
		No.	♀	No.	♂	No.	♂	
						No.	♀	
				No.	♀	No.	♂	
No.	No.					No.	♀	

Sheet No.					Go to Sheet
Sex	♂	No. ♂	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
				No. ♀	
		No. ♀	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
	No.			No. ♀	
	♀	No. ♂	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
				No. ♀	
		No. ♀	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
No.	No.			No. ♀	

Sheet No.	♂	No. ♂	No. ♂	No. ♂	Go to Sheet
				No. ♀	
			No. ♀	No. ♂	
				No. ♀	
Sex		No. ♀	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
				No. ♀	
	No.				
	♀	No. ♂	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
				No. ♀	
		No. ♀	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
No.	No.			No. ♀	

Sheet No.	Sex	No.	♂	♀	No.	♂	♀	No.	♂	♀	No.	♂	♀	Go to Sheet

Sheet No	Sex	No.	♀	No.	♀	No.	♂	No.	♂	Go to Sheet
		No.	♂	No.	♂	No.	♀	No.	♀	
		No.	♀	No.	♀	No.	♂	No.	♂	
		No.	♂	No.	♂	No.	♀	No.	♀	
		No.	♀	No.	♀	No.	♂	No.	♂	
		No.	♂	No.	♂	No.	♀	No.	♀	
		No.	♀	No.	♀	No.	♂	No.	♂	
		No.	♂	No.	♂	No.	♀	No.	♀	
		No.	♀	No.	♀	No.	♂	No.	♂	

Sheet No.	♂	No. ♂	No. ♂	No. ♂	Go to Sheet
				No. ♀	
			No. ♀	No. ♂	
				No. ♀	
		No. ♀	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
				No. ♀	
Sex	No.				
	♀	No. ♂	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
				No. ♀	
		No. ♀	No. ♂	No. ♂	
				No. ♀	
			No. ♀	No. ♂	
No.	No.			No. ♀	

CHAPTER VI

Organizing a Good Sales Pedigree

While the construction of a good sales pedigree does not belong primarily to a course devoted chiefly to a study of breeding principles, the fact that success in a commercial sense is so largely dependent on the legitimate exploitation of all surplus breeding stock justifies the inclusion of this subject. Furthermore, the purchaser's proper evaluation of such a pedigree for the breeding worth of the animal in question requires a knowledge of how such pedigrees are constructed and the weight to be attached to the information given in them. In this sense the construction of such a pedigree furnishes a good ground work, to direct the student's attention to specific problems of breeding.

The first step in commercial pedigree work is to trace the pedigree of the animal in the manner shown in the previous exercise. The next step is to add the records for production. The following information should be given for each bull.

A. Number of record daughters.
B. Citation of records of some of the daughters featuring those which are best.
C. Number of proven sons (sons who in turn have record daughters).
D. Citation of records of some of the best of the proven sons' record daughters.
E. Number of proven granddaughters and their exceptional records.
F. Records of the dam and granddam, when commendable.
G. Records of brothers or sisters, if striking.
H. Records of other famous ancestors which would tend to enhance the value of the animal pedigreed.

For the cow similar records are given, including first her own record.

The present custom seems to require that all animals in the pedigree up to the fourth generation have some citation to records which would indicate their merit. The hardest pedigree to make attractive is the one in which the ancestors have few available records.

Here is where the able salesman makes his money. Fill in two of the pedigrees with the information to show the breeding worth of the animal pedigreed. It is suggested that the first of these pedigrees be for one of the Advanced Registry animals and the other for one of the random sample animals. Both of the pedigrees should be presented in sales catalog style. Chapters IX to XXIV of *M. S.* furnish information by which to evaluate the significance of different sorts of ancestors' records in predicting the milk yield or butter-fat percentage of a cow.

REFERENCES

Sales catalogues of good companies furnish one of the best sources for models of how this work should be done.

Prescott, M. S., and Prescott, W. A. 1923. *The Holstein-Friesian Foundation*, Holstein-Friesian World, Inc., Syracuse, N. Y., gives some extensive pedigrees of high record cows with pedigree production records.

CHAPTER VII

Characteristics of Pedigrees in the Different Breeds

INBREEDING

The distinction between inbreeding and line breeding is so hazily drawn that it is futile to consider them separately. The system of measuring inbreeding which is presented is that of Pearl. Chapter IV of Dr. Raymond Pearl's book on *Modes of Research in Genetics* should be consulted for a discussion of the method of measuring inbreeding before the student commences his own work.

Inbreeding is noticed in any pedigree if within that pedigree there are two or more ancestors which are identical. In other words the different ancestors of an inbred animal are less in number than if that animal were not inbred. A purely objective measure of inbreeding is, then, the ratio between the number of different ancestors in one generation to the total possible number of ancestors. This is the measure used in this work. The pedigree of Rioter's Jersey Lad illustrating its calculation is given on page 45.

The animals marked with the solid circles are repeated previously in the pedigree. Those marked with an open circle containing a cross are ancestors of repeated animals. In this pedigree, the repeated animals are Ida's Rioter of St. Lambert, Bachelor of St. Lambert, Ida of St. Lambert and Ida's Stoke Pogis. The generations are numbered A_1, A_2, A_3, A_4. The coefficient of inbreeding is represented by Z. There are always two ancestors in A_1, consequently there is no inbreeding or $Z_0 = 0$. In the second generation, A_2, there are four possible ancestors and all four are different so there is no inbreeding, $Z_1 = 0$. In the third generation, A_3, Ida's Rioter of St. Lambert reappears, so there is inbreeding. The amount of this inbreeding is equal to 1, the number of repeated ancestors, divided by 8 the possible number of ancestors, or 12.5 per cent of the inbreeding. In the fourth generation, there are 5 animals repeated, namely, Bachelor of St. Lambert (twice)

Ida of St. Lambert (twice) and Ida's Stoke Pogis (once). The number of total possible ancestors is 16 or the inbreeding, $Z_3 = \frac{5}{16}$ or 31.25 per cent.

The student may calculate the inbreeding found in each of his four pedigrees. Tabulate the inbreeding of the pedigrees for the whole class, tabulating each group of pedigrees separately—Advanced Registry bulls, Advanced Registry cows, random sample bulls, random sample cows. The protocol for this tabulation is given on pages 46–49. Comparing the average per cent of inbreeding for each group, what conclusion do you draw as to the influence of inbreeding on the possibilities of an animal's having an Advanced Registry record? Read Chapter VII in *M. S.* Sections relating to inbreeding in:

REFERENCES

Pearl, R., Gowen, J. W., and Miner, J. R. 1919. *Studies in Milk Secretion VII. Transmitting qualities of Jersey sires for milk yield, butter-fat percentage, and butter-fat,* Maine Station Bulletin 281.

Wright, Sewall. 1922. *The effects of inbreeding and crossbreeding on guinea pigs,* U. S. Department of Agriculture, bulletins 1090 and 1121.

King, Helen D. 1918, 1919, 1921. *Studies in inbreeding,* Jour. Exper. Zoöl., vol. 26, pp. 1–98; vol. 27, pp. 1–37; vol. 29, pp. 134–175.

Write a paper of 250 words giving a synopsis of the conclusions you draw from your studies as to the influence of inbreeding.

Sheet No.	Sex					Go to Sheet
No. 58001 Rioter's Jersey Lad	♂	No. 13656 ♂ Ida's Rioter Of St. L	No. 4558 ♂ Bachelor of St. L	No. 3143 ♂ Orloff		
				No. 6638 ♀ Charity of St. L		
			No. 24990 ♀ Ida of St. L	No. 2238 ♂ Stoke Pogis 3d		
				No. 5122 ♀ Kathleen of St. L		
		No. 62474 ♀ Dew	No. 13656 ♂ ●Ida's Rioter of St.L	No. 4558 ♂ ⊕Bachelor of St. L.		
				No. 24990 ♀ ⊕Ida of St. L		
			No. 8612 ♀ Lady Appel	No. 2219 ♂ Young St. Martin		
				No. 5900 ♀ Isolda		
	♀	No. 19289 ♂ Pogis Lad	No. 13658 ♂ Ida's Stoke Pogis	No. 4558 ♂ ●Bachelor of St. L		
				No. 24990 ♀ ●Ida of St. L		
			No. 12213 ♀ Daisy Brown	No. 3533 ♂ Tormentor		
				No. 9522 ♀ Heedless		
		No. 59836 ♀ Lily Adonis	No. 20881 ♂ Wrangler	No. 17236 ♂ Roonan's Signal		
				No. 17615 ♀ Baron's Sophie		
			No. 49954 ♀ Lily Martin	No. 13658 ♂ ●Ida's Stoke Pogis		
				No. 32915 ♀ Sigletta		

No. 41012 Ida's Rioter of St. L. 11th

No. 99422 Lad's Lilly

NO.	NAME OF BULL GROUP (ADVANCED REGISTRY BULL)	H.B.No.	Z_1	Z_2	Z_3

NO.	NAME OF COW GROUP (ADVANCED REGISTRY COW)	H.B.No.	Z_1	Z_2	Z_3

NO.	NAME OF BULL GROUP (RANDOM SAMPLE BULL)	H.B.No.	Z_1	Z_2	Z_3

NO.	NAME OF COW GROUP (RANDOM SAMPLE COW)	H.B.No.	Z_1	Z_2	Z_3

CHAPTER VIII

Characteristics of Pedigrees for the Different Breeds

RELATIONSHIP

Within any pedigree a state of relationship exists if the sire and dam of the animal pedigreed have common ancestors, or putting it another way, two individuals are related if they have common ancestors. The calculation of the relationship coefficients is much like that for inbreeding save for one particular, namely, that for any one generation it is possible to have only half the number of animals related as compared with those which are inbred. Such being the case the denominator of the fraction in any generation is half the number of animals in that generation. The coefficient of kinship or relationship is noted by K.

Turning back to the pedigree of Rioter's Jersey Lad, we note that there are no common ancestors for the sire and dam up to the fourth generation. Such being the case K_2 and K_3 are both 0 in value. In the fourth generation A_4, Bachelor of St. L. and Ida of St. L. are common to both sire and dam so that the coefficient of relationship is 2 divided by 8 or 25 per cent.

The student may calculate the kinship found in each of his four pedigrees. Tabulate the kinship coefficients for the pedigrees of the whole class, tabulating each group separately as was done for the inbreeding. See pages 51–54 for protocols. Compare the average per cent of relationship found in the pedigrees of the four groups. What conclusion do you draw as to the influence of relationship on the recorded producing power of an animal.

REFERENCES

Read Chapters II and VII of *M. S.* for the discussion of kinship.

Maine Station Bulletin 281, *Studies in milk secretion VII.*

Pearl, Raymond. September, 1917. *Studies on inbreeding VII*, American Naturalist, vol. LI, pp. 454–559.

Other sources of information will be suggested by these references which it would be well for the student to follow up. Write a short paper on the influence of relationship.

NO.	NAME OF BULL GROUP (ADVANCED REGISTRY BULL)	H.B.No.	K_1	K_2	K_3

NO.	NAME OF COW GROUP (ADVANCED REGISTRY COW)	H.B.No.	K_1	K_2	K_3

NO.	NAME OF BULL GROUP (RANDOM SAMPLE BULL)	H.B.No.	K_1	K_2	K_3

NO.	NAME OF COW GROUP (RANDOM SAMPLE COW)	H.B.No.	K_1	K_2	K_3

CHAPTER IX

Characteristics of Pedigrees for the Different Breeds. Homozygosis Resulting from Different Types of Matings

The reader will recall that an individual which is homozygous for a large number of factors will tend to have offspring more like himself than will an individual which is heterozygous for a wide number of factors. A sire homozygous for dominant factors will, consequently, practically always reproduce his kind, or be prepotent. The degree of homozygosis of a sire or cow is consequently of considerable importance to the breeder. The degree of homozygosis also has a further significance, in that a method of breeding which rapidly increases homozygosis in each generation tends to do two things—lessen the vigor of the offspring as measured by weight, fertility, and health, and second, increase the uniformity of the stock and consequently the prepotency in outside crosses.[1] Wright has indicated the methods by which the degree of homozygosis of an individual may be determined. The results give the probable average homozygosis as a per cent based on the assumption that the original ancestors were themselves random bred.

REFERENCES

In case the reader has not already done so it would be of interest for him to read:

Wright. 1921. *Systems of mating 1 to 5*, Genetics, vol. 6, pp. 111–178.

Wright. 1922. *Coefficients of inbreeding and relationship*, American Naturalist, vol. 56, pp. 330–338.

As an illustration of the method, I take the pedigree of King Walker 40358, a Holstein-Friesian bull (see page 56).

[1] A word of comment should be added, while these effects are the average results of increase in homozygosis they may be avoided by careful selection to isolate the superior lines of the stock in each generation. This result brings in another agent, selection, which must be rigorously used on many characters to result in superior lines of homozygous stock.

Sheet No.	Sex					Go to Sheet
No. 40358 King Walker	♂	No. 25755 ♂ Admiral Walker	No. 21530 ♂ Capitola Duke	No. 18342 ♂ Alph Terpstra		
				No. 13050 ♀ Capitola H.		
			No. 38944 ♀ Lillian Walker	No. 20383 ♂ Pietertje Waldorf		
				No. 35159 ♀ Bessie Welsrijp's Beauty		
		No. 49308 ♀ Mary R. Pietertje	No. 23027 ♀ Gold Boy Pietertje	No. 21229 ♂ Gold Gem Pietertje		
				No. 5393 ♀ Kate H.		
			No. 35167 ♀ Rosa Pietertje	No. 14218 ♂ Pietertje Hartog		
				No. 20501 ♀ Lucy Rosamond		
No. 64169 Lillian Walker Pietertje	♀	No. 25755 ♂ Admiral Walker ●	No. 21530 ♂ Capitola Duke ⊕	No. 18342 ♂ Alph Terpstra ⊕		
				No. 13050 ♀ Capitola H. ⊕		
			No. 38944 ♀ Lillian Walker ⊕	No. 20383 ♂ Pietertje Waldorf ⊕		
				No. 35159 ♀ Bessie Welsrijp's Beauty ⊕		
		No. 53334 ♀ Beauty Pietertje	No. 23469 ♂ Lebanon Pietertje Prince	No. 22324 ♂ Inka Princess' Pietertje Pledge		
				No. 38944 ♀ Lillian Walker ●		
			No. 40082 ♀ Prilly	No. 20214 ♂ Plum 4th's Joe		
				No. 17498 ♀ Patty's Gelsche		

In this method of calculation, the percentage of homozygosis under random mating is assumed to be 50 per cent. The average percentage of homozygosis is equal to $\frac{1}{2}$ $(1 + f_0) \times 100$, or on a percentage scale of 0 to 100 for the increase of homozygosis from 50 to complete homozygosis, 100 per cent, the value of

$$f_0 = S\,(\tfrac{1}{2})^{n+n'+1}\,(1 + f_a)$$

where S equals summation.

It is possible to consider f_0 as Wright does, a coefficient of inbreeding. It is perhaps more properly the percentage increase of homozygosis brought about by the system of breeding. To increase homozygosis the ancestor must be common to both sire and dam. The n and n' are the number of generations from sire and dam respectively to the ancestor common to each. If the common ancestor is inbred, its coefficient of inbreeding f_0 must be worked out for his pedigree first. Otherwise the value of f_0 is considered zero.

The steps in the calculation of the pedigree of King Walker are as follows: King Walker has as common grandsire Admiral Walker. He also traces through the paternal grandsire and maternal granddam to Lillian Walker. All common lines tracing back from the sire to the common ancestor and thence forward to the dam and passing through no individual more than once are thus included. In tabular form we have f_0 as given in the following protocol.

INDIVIDUAL	COMMON ANCESTORS OF SIRE AND DAM	fa	n	n'	$(\frac{1}{2})^{n+n'+1}\,(1+fa)$
King Walker 40358	Admiral Walker 25755	0	1	1	0.1250
	Lillian Walker 38944	0	2	3	0.0156
					0.1406

or the per cent of probable homozygosis $\frac{1}{2}$ $(1 + 0.1406) = 57.03$.

As another illustration, the pedigree of the Holstein-Friesian cow Korndyke Butter Girl Johanna 2d, 183646 may be taken (see p.58). This pedigree displays a fairly large amount of inbreeding. The animals repeated first are Korndyke Butter Boy, Johanna Aaggie 2d's Lad, Manor DeKol. The animals found in the pedigree of the repeated animals are shown as the open circles containing the cross. Korndyke Butter Boy is himself inbred so that it is neces-

Sheet No.	Sex					Go to Sheet
No. 183646 Korndyke Butter Girl Johanna-2d	♀	No. 53405 Sir Johanna Butter Boy	♂	No. 38496 ♂ Korndyke Butter Boy	No. 23260 ♂ DeKol 2d's Butter Boy 3d	No. 21226 ♂ Manor DeKol	
						No. 734 ♀ DeKol 2d	
					No. 41934 ♀ Korndyke Queen DeKol	No. 21226 ♂ Manor Dekol ●	
						No. 13913 ♀ Belle Korndyke	
				No. 71788 ♀ Hetje May Johanna	No. 26941 ♂ Johanna Aaggie 2d's Lad	No. 23971 ♂ Sarcastic Lad	
						No. 45165 ♀ Johanna Aaggie 2d	
					No. 42599 ♀ Hetje 6th's Lady May	No. 23228 ♂ Ybma's 3d's Pietertje	
						No. 30848 ♀ Hetje 6th	
No. 107438 Korndyke Butter Girl Johanna	♀			No. 38496 ♂ Korndyke Butter Boy ●	No. 23260 ♂ DeKol 2d's Butter Boy 3d ⊕	No. 21226 ♂ Manor DeKol ⊕	
						No. 734 ♀ DeKol 2d ⊕	
					No. 41934 ♀ Korndyke Queen DeKol ⊕	No. 21226 ♂ Manor DeKol ⊕	
						No. 13913 ♀ Belle Korndyke ⊕	
				No. 64807 ♀ Johanna Pel	No. 26941 ♂ Johanna Aaggie 2d's Lad ●	No. 23971 ♂ Sarcastic Lad ⊕	
						No. 45165 ♀ Johanna Aaggie 2d ⊕	
					No. 52775 ♀ Pel DeKol	No. 23923 ♂ Senor Paul DeKol	
						No. 13299 ♀ Sinnema's Pel 2d	

sary to calculate his contribution to the homozygosis before calculating that of Korndyke Butter Girl Johanna 2d. Following the protocol we have the results shown below.

INDIVIDUAL	COMMON ANCESTORS OF SIRE AND DAM	fa	n	n'	$(\frac{1}{2})^{n+n'+1}(1+fa)$
Korndyke Butter Boy 38496	Manor DeKol 21226	0	1	1	0.1250
Korndyke Butter Girl Johanna 2d 183646	Korndyke Butter Boy 38496	0.125	1	1	0.1406
	Johanna Aaggie 2d's Lad 26941	0	2	2	0.0313
					0.1719

The percentage of homozygosis is $\frac{1}{2}(1 + 0.1719) \times 100 = 58.60$ per cent.

With these illustrations before us the complete significance of this coefficient may be considered further. As indicated above the coefficient gives the percentage increase of homozygosis or conversely the percentage decrease in heterozygosis, when the animal pedigreed has its unknown ancestors random mated. Thus the coefficient really gives the percentage decrease in heterozygosis relative to the stock to which the pedigrees are traced. If the percentage of heterozygosis happens to be 50 per cent in the latter stock, $\frac{1}{2}(1 + F_0) \times 100$ gives the percentage of homozygosis in the animals dealt with. In general, if p' is the percentage of heterozygosis in this foundation stock, the percentage of heterozygosis in the animal 0 is $p_0 = p'(1 - F_0) \times 100$. The assumption of previous random mating for the fourth generation animals in any fourth generation pedigree is undoubtedly not correct. While the actual percentage of heterozygosis in any stock can hardly be estimated, it is probably low when all the factors for the inherited characteristics of the species, genus, order, and phylum are considered. Thus what is really calculated, a point Wright is very careful to emphasize, is the degree of change in the direction of homozygosis. The importance of the coefficient F_0 is not to be minimized by these considerations but rather strengthened.

Calculate the amount of homozygosis for each of the pedigrees. Tabulate the results for the whole class in the four groups, Ad-

vanced Registry bulls and cows, random sample bulls and cows. Protocols for these tabulations are found on pages 61–65.

REFERENCE

Wright's paper in 1923 on *Mendelian Analysis of the Pure Breeds*, II, *The Dutchess Shorthorns*, Journal Heredity, vol. XIV, pp. 405–422.

INDIVIDUAL	COMMON ANCESTORS OF SIRE AND DAM	*fa*	*n*	*n'*	$(\frac{1}{2})^{n+n'+1}(1+fa)$

NO.	ADVANCED REGISTRY GROUP, BULLS		PERCENTAGE OF HOMOZYGOSIS
	Individual	Herd book No.	

NO.	ADVANCED REGISTRY GROUP, COWS		PERCENTAGE OF HOMOZYGOSIS
	Individual	Herd book No.	

NO.	RANDOM SAMPLE GROUP, BULLS		PERCENTAGE OF HOMOZYGOSIS
	Individual	Herd book No.	

NO.	RANDOM SAMPLE GROUP, COWS		PERCENTAGE OF HOMOZYGOSIS
	Individual	Herd book No.	

CHAPTER X

Characteristics of Pedigrees

FAMOUS ANCESTORS

Statements like the following, make it desirable for the student to have an accurate acquaintance with the foundation animals in any breed.

> Of all the nearly eight thousand animals.....imported.....the real foundation of the aristocracy rests upon about three dozen.....animals. It is impossible to measure exactly the contributions of the other 99 per cent of imported animals, but the preponderance of this small group.....in the pedigrees of our leading producers in both short-time and long-time tests and of our leading show ring winners as well, leads straight to the conclusion that it is prepotency of these blood lines that has been responsible for the supremacy of the breed.

Each student may take the names of each ancestor in the pedigrees he has just made, one ancestor for each slip. The cards found between manual pages 67–68 form an easy method of handling these data. A sample of the way one of these cards is made out is shown for Sir Johanna Butter Boy sire of Korndyke Butter Girl Johanna 2d.

Herd Book No. 53405

Name of Ancestor
Sir Johanna Butter Boy Sex Male

Generation First

In pedigree of Korndyke Butter Girl Johanna 2d 183646

The red slips are for the Advanced Registry bulls, green for the Advanced Registry cows, blue for the random sample bulls, and white for the random sample cows. In this way the different sets of pedigree data will not be mixed. When each student has arranged this data on the slips, have the slips of the whole class combined into four groups (Advanced Registry bulls, Advanced Registry cows,

Herd Book No.....

Name of Ancestor..... Sex.....

Generation.....

In pedigree of.....

Herd Book No.....

Name of Ancestor..... Sex.....

Generation.....

In pedigree of.....

Herd Book No.....

Name of Ancestor..... Sex.....

Generation.....

In pedigree of.....

Herd Book No.....

Name of Ancestor..... Sex.....

Generation.....

In pedigree of.....

Herd Book No..... .....

Name of Ancestor..... Sex.....

Generation.....

In pedigree of.....

Herd Book No. .....

Name of Ancestor..... Sex.....

Generation.....

In pedigree of.....

random sample bulls, random sample cows). Have each group sorted in order of the herd book number of the ancestor, tabulate the frequency of the appearance of the different ancestors in each group; arrange in order of the frequency of appearance. Pages 68–72 give form tables to summarize most frequent ancestors. What do you conclude as to the ancestors found in the different groups of pedigrees? Are they different or are they the same? Do you note any significant difference between the four groups? Would the appearance of the most frequently appearing animal in the Advanced Registry group indicate the probable worth of any unknown animal? What would you consider the great families of the breed?

After reading the following references write a short paper on this subject emphasizing especially its possible importance to production. Define family and write of interesting facts connected with each for the breeds you have studied. Critically review the data given in these references.

REFERENCES

M. S., chapters II and VII.

Hunt, R. E. 1921. *Who's who among Holstein-Friesian sires*, Va. Agr. Col. Ext. Bul. 66, pp. 14.

Hoven, J. M. 1916. *Finding the prepotent sire*, Jour. Heredity, vol. 7, pp. 173–178.

Prescott, M. L., and W. A. 1923. *Holstein-Friesian Foundations*, Holstein-Friesian World, Inc., Syracuse, New York.

Maine Station Bul., 281, 300, and 301.

Frequency of Appearances of Different Ancestors in Advanced Registry

Bull Groups

BULLS NUMBER OF ANCESTOR	NUMBER OF APPEARANCES IN GIVEN GENERATION				
	First	Second	Third	Fourth	Total
COWS					

Frequency of Appearance of Different Ancestors in Advanced Registry Cows Groups

BULLS NUMBER OF ANCESTOR	NUMBER OF APPEARANCES IN GIVEN GENERATION				
	First	Second	Third	Fourth	Total
COWS					

Frequency of Appearances of Different Ancestors in Random Sample

Bulls Group

BULLS NUMBER OF ANCESTOR	NUMBER OF APPEARANCES IN GIVEN GENERATION				
	First	Second	Third	Fourth	Total
COWS					

Frequency of Appearances of Different Ancestors in Random Sample Cows Group

BULLS NUMBER OF ANCESTOR	NUMBER OF APPEARANCES IN GIVEN GENERATION				
	First	Second	Third	Fourth	Total
COWS					

Summary Sheet for Frequency of Appearances of Different Ancestors in Different Pedigree Groups. Animals Arranged in Order of the Total Number of Appearances, the Highest Coming First.

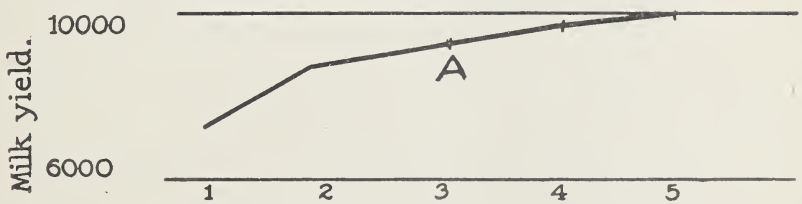
BULLS NUMBER	NAME	NUMBER OF APPEARANCES IN DIFFERENT GROUPS				Total
		Advanced Registry group		Random Sample group		
		Bulls	Cows	Bulls	Cows	
COWS						

CHAPTER XI

Conformation in Relation to Milk Yield

This method of estimating the probable milk yield of a cow is of the rough and ready type. It is always available to the purchasers where milk records are not. Furthermore conformation gives an estimate of other qualities valuable in the cow besides the milk yield itself, as for instance, present condition of the udder, type of cow in relation to gestation, etc. The study of conformation in relation to milk yield may be approached in the laboratory as follows—the class is supposed to have had a course in stock judging or its equivalent. The following information on the breed of animals they are studying should be given the students: the lowest, average, and the highest yearly milk yields of the cows in the breed as attained in the college barn. Place all of the animals now in the herd, estimating the probable yearly milk yield of each. After returning from the barn to the class room the actual yearly production of each cow should be procured. A three column protocol furnishing the necessary space is given on page 75.

To bring out the facts of these data they may be arranged as follows. Arrange the student's estimate of yearly production in order from lowest to highest. Divide the whole data into five groups with equal numbers of cows. Calculate the average actual milk yield for the cows of each group. Plot these averages on coördinate paper on page 76 as shown in the protocol below.



If line *A*, formed by connecting the five points, has a general trend upward as the student's estimate of production increases, it shows

the student that he can judge cattle and pick out the better milkers. If it descends, it shows the student that he chooses the poorer milkers for the best and vice versa.

Note: The method suggested is of course a rather crude test of this subject. It will, however, bring out the problem and set any student thinking about it. The correlation method can be substituted where it is desired to do it.

The student should write a short paper discussing results and present day significance of cattle judging especially in regard to practical dairying, using the following references to the history.

REFERENCES

M. S., Chapter III.

Gowen, John W. 1920. *Conformation and its relation to milk producing capacity in Jersey cattle,* Jour. Dairy Science, vol. III, pp. 1–32.

Gowen, John W. 1921. *Conformation and its relation to milk producing capacity in Jersey cattle. II. The personal equation of the cattle judge,* vol. IV, pp. 359–374.

Aldrich, A. M., and Dana, J. W. 1916. *The relation of the milk veins system to production,* Bul. 202 Vermont Agr. Expt. Sta., pp. 1–24.

Graves, R. R. 1916. *An experiment with milk veins,* Hoards' Dairyman, III, pp. 687 and 717.

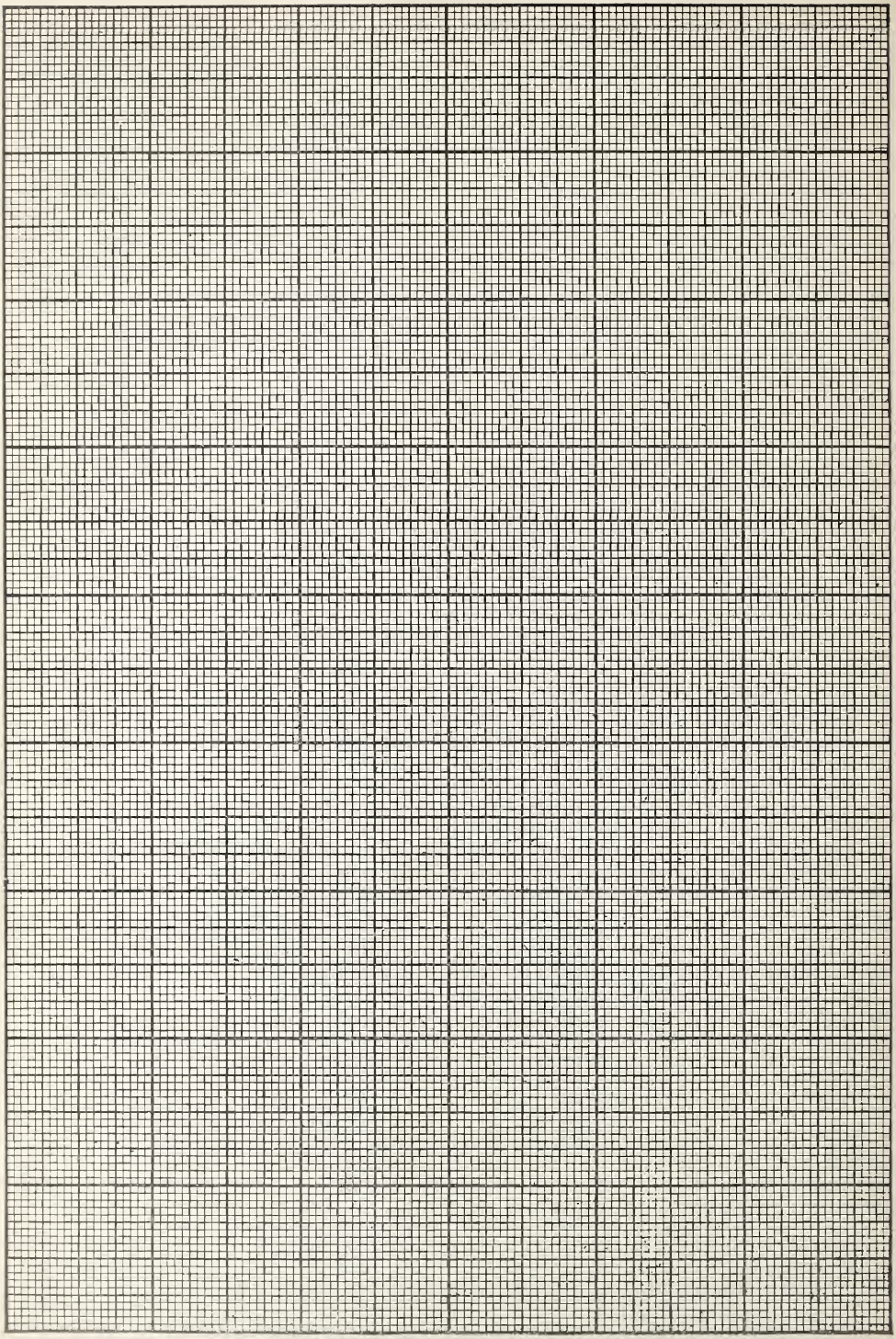
Col. Le Couteur. 1845, 1851. Contribution to this subject in Jersey cattle is given in Jour. Royal Agr. Society of England, vol. V and vol. XII, part 2. These two papers are of much historical interest.

Conformation in Relation to Milk Yield

Breed Studied.....

Range of Yearly Milk Yield.....

NAME OF COW	STUDENTS ESTIMATE OF YEARLY PRODUCTION	ACTUAL MILK YIELD



CHAPTER XII

Age of the Cow in Relation to Milk Yield

The collection of data for this subject requires so much effort that the student must, practically speaking, take the scatter table of others for granted. For illustrative purposes, I take the tables for the relation of 365-day Guernsey milk yield with age. This is the ordinary correlation table used to show the relation of one variable to another (see page 78).

The way in which such a table is made is as follows: Cards showing these records are first sorted into age groups of six months, beginning at one year and six months. These groups represent the frequency distribution shown under "Total" at the right. They are then sorted for the milk yield groups as shown above the table. The frequency distribution for each age is consequently the variation of milk yield for each six months of age.

If milk yield is related to age, the mean milk yields would be expected to rise or fall in some definite manner with increase in age. To get the mean milk yields for the age groups we adopt the method of arbitrary origins and call each class an increase of unity over the preceding class. The top line marked X shows these classes. The $S(x)$ (summation x) of each row is found by multiplying the number in the row by the class unit in X and adding. Thus for the first row:

$$(7 \times 1) + (44 \times 2) + (69 \times 3) + (52 \times 4) + (42 \times 5) + (17 \times 6) + (9 \times 7) + (3 \times 8) + (1 \times 9) = 918$$

The mean milk yield of the first row may be obtained from this data by the following method:

$$\frac{918}{244} = \frac{s(x)}{n} = 3.762295$$

or in other words the mean milk yield of the row is 3.762295 units away from our arbitrary origin. Now each unit is equal to 1000

AGE AT COMMENCEMENT OF TEST	MILK YIELD (365-DAY)																							
	4000–5000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000	20000	21000	22000	23000	24000–25000	Total		
(*X*)	(*1*)	(*2*)	(*3*)	(*4*)	(*5*)	(*6*)	(*7*)	(*8*)	(*9*)	(*10*)	(*11*)	(*12*)	(*13*)	(*14*)	(*15*)	(*16*)	(*17*)	(*18*)	(*19*)	(*20*)	(*21*)		(*Y*)	
1:6- 2:0	7	44	69	52	42	17	9	3	1													244	1	918
2:0	26	219	489	577	467	344	176	85	26	20	5	2										2,436	2	11,063
2:6	2	74	199	300	272	203	127	66	28	6	6	1	1	1	1							1,287	3	6,374
3:0	2	30	152	233	211	160	107	68	31	14	10		1	1								1,020	4	5,314
3:6		13	86	167	190	188	123	73	66	16	9	3	4		1							939	5	5,431
4:0		6	46	130	176	140	118	86	60	22	11	10	4	1								810	6	4,971
4:6		1	35	80	159	116	94	84	55	37	16	11	4	1								693	7	4,487
5:0			7	52	108	100	90	55	57	36	11	13	5	1	1		1					537	8	3,700
5:6		1	9	44	90	103	90	64	46	35	13	4	3	1	1							504	9	3,438
6:0			6	45	69	86	74	78	41	20	9	13	4	5	2	3						455	10	3,225
6:6		1	5	27	77	75	62	46	41	15	15	7	4	1	1	1						378	11	2,627
7:0			4	15	43	55	63	45	23	13	12	8	5	3	3							292	12	2,135
7:6			5	14	33	46	47	29	26	9	7	2	9	2	1							230	13	1,658
8:0			3	14	24	35	42	25	22	22	8	6	2	1								204	14	1,507
8:6			1	11	17	22	25	23	13	8	7	3	3								1	134	15	993
9:0			1	8	23	28	22	17	15	10	4	4	3	1		1						137	16	1,004
9:6			3	9	12	23	19	14	7	8	9	4		1								109	17	792
10:0				7	12	11	13	8	9	4	2	3	2									71	18	514
10:6			2	2	8	9	6	2	9	2	3			1								44	19	314
11:0			1	3	5	8	5	4	4	1	2			1								34	20	237
11:6			1	2	5	7	5	2	3		1											26	21	167
12:0				1	2	4	4	3	1	1			1									17	22	122

12 6				1	1	7			1	1	1										12	23	81
13.0			1	2	3	4		2	1	1											14	24	85
13:6				1	3	1	1		1												7	25	41
14:0					1	1	1														3	26	18
14:6												1									1	27	12
15:0				1	1			1													4	28	21
15:6																							
16:0																							
16:6					1																1	31	5
17:0																							
17:6–18:0				1																	1	33	4
	37	389	1,125	1,800	2,055	1,793	1,323	883	587	301	161	95	55	22	11	5	1			1	10,644		61,258

pounds of milk as seen from the method in which the table is grouped. The value of X is assumed to equal the mid-point of that particular group so that $X = 1$ is really equal to 4500 pounds of milk. The zero origin is consequently equal to 4500 − (1, the value of X, multiplied by 1000, the class interval) or 3500. Then the mean of the first group is equal to

$$3500 + 3.762295 \times 1000 = 7262.3 \text{ pounds of milk}$$

In like manner the other average milk yields for the different ages may be obtained. These are shown in the following table.

AGE AT TEST	MEAN MILK YIELD
1 year 6 months to 1 year 11 months	7,262
2 years 0 months to 2 years 5 months	8,042
2 years 6 months to 2 years 11 months	8,453
3 years 0 months to 3 years 5 months	8,710
3 years 6 months to 3 years 11 months	9,284
4 years 0 months to 4 years 5 months	9,637
4 years 6 months to 4 years 11 months	9,975
5 years 0 months to 5 years 5 months	10,390
5 years 6 months to 5 years 11 months	10,321
6 years 0 months to 6 years 5 months	10,598
6 years 6 months to 6 years 11 months	10,450
7 years 0 months to 7 years 5 months	10,812
7 years 6 months to 7 years 11 months	10,709
8 years 0 months to 8 years 5 months	10,887
8 years 6 months to 8 years 11 months	10,910
9 years 0 months to 9 years 5 months	10,829
9 years 6 months to 9 years 11 months	10,766
10 years 0 months to 10 years 5 months	10,739
10 years 6 months to 10 years 11 months	10,636
11 years 0 months to 11 years 5 months	10,471
11 years 6 months to 11 years 11 months	9,923
12 years 0 months to 12 years 5 months	10,677
12 years 6 months to 12 years 11 months	10,250
13 years 0 months to 13 years 5 months	9,571
13 years 6 months and above	9,441

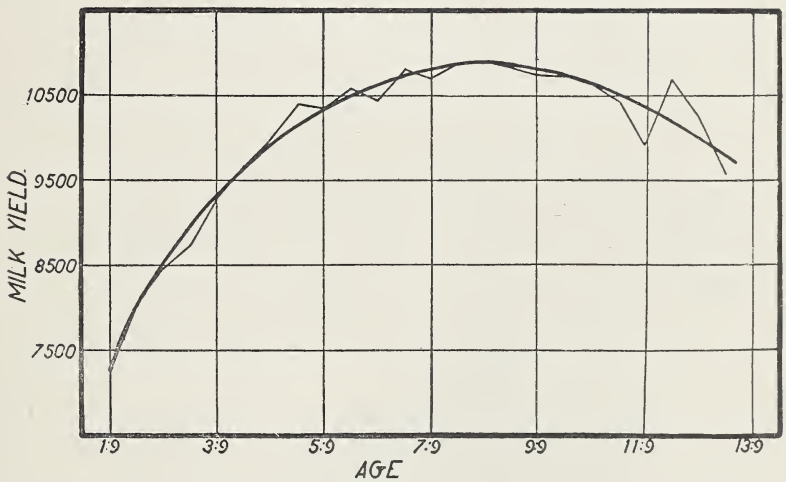
(The different members of the class may check the results for the different rows.) The student by plotting these means shows that there is a relation between milk yield and age of the cow. To place the milk yields of cows on comparable age basis we might use

the relation of these raw average milk yields at one age to those of a constant age, say 8 years. However, it is better to determine the curve for the data thus eliminating the irregularities due to lack of numbers. Such a curve may be fitted to these data by the method of least squares. When thus fitted the curve is found to be:

$$\text{Mean milk yield} = 6372.6 + 827.9a - 51.8a^2 + 1394.6 \log (a - 1.25)$$

where the age (a) is in years and the origin is zero years.

The student may calculate the points in this curve for each six months of age beginning with 1 year 9 months and plot them on his plot of the raw average milk yield. The completed figure on page 85 when plotted from data of page 86 will be like that shown below.



From these data the correction factors of milk yield for age may be determined. These factors are taken as the ratio of the milk yield at 8 years divided by the milk yield at the age from which correction is made. Thus the correction factor for the milk yields of cows at 2 years to the eight year standard would be

$$\frac{10837.2}{7647.0} \text{ or } 1.417^*$$

* This method of determining the correction factors for age and milk yield is the one customarily employed with results which are satisfactory for practical purposes. A slightly more exact method takes into account not only the changes in the mean milk yields with age but also the changes in the

That is if a cow has a record of 8000 pounds as a two-year-old and we wish to get her probable record at 8 years we multiply 8000 × 1.417 or the probable record is 11,337 pounds.

The class should determine these correction factors for different ages entering their results on pages 8–87 and make a table similar to that given in Maine Station Bulletin 311, page 17.

The student will find a good deal of interest in making comparisons like these. Murne Cowan, 19797, has three records for Advanced Registry. Each record is for the year period. The first record is for 16,729 pounds of milk at 6 years 3 months of age. The second record is for 24,008 pounds of milk at 8 years 9 months of age. The third record is for 17,384 pounds of milk at 11 years 1 month of age. If we examine table 4 in Maine Station Bulletin 311 we note that in the six year age row, at 17,000 pounds of milk (column 15) the expected production of this cow at 8 years would be 17,682 pounds instead of the 24,008 pounds she actually produced. In other words, her production was 6326 pounds more than was expected. Before considering this difference, let us examine the third record. Figure 3 of this bulletin shows that, on the average, the cows at 11 years 1 month produce slightly more milk than those at 6 years 3 months. The 6 year 3 month record of Murne Cowan would consequently predict a record of about 17,000 pounds at 11 years 1 month old or a record closely similar to that actually made. This illustration brings out a true biological fact concerning milk records. The phenomenal record is made under such pressure that the cow, herself, and every condition surrounding her must be most favorable. Furthermore, the most favorable conditions for one cow may not be favorable to another so that it is extremely hard to duplicate the conditions which are favorable. The high records tend to be made when the cows are in the pink

variation of milk yield with age. The formula which determines this relation is milk yield at standard age (Y_s) equals milk yield at x age (Y_x) multiplied by standard deviation of the milk yield at standard age (σ_s) divided by standard deviation at x age (σ_x), minus mean milk yield at x age ($\overline{Y}_x$) multiplied by standard deviation at standard age (σ_s) divided by standard deviation at x age (σ_x), plus average milk yield at standard age ($\overline{Y}_s$) or

$$Y_s = \frac{Y_x \sigma_s}{\sigma_x} - \frac{\overline{Y}_x \sigma_s}{\sigma_x} + \overline{Y}_s$$

where the overlined value represents mean values.

of condition for making high records, the low records when the conditions are unfavorable. There is a tendency for high and low record cows when retested to have their records regress toward the average of the breed, due to the change in conditions surrounding the cow. The correction on the basis of the mean curve takes no cognizance of the environmental conditions but assumes that the conditions remain as they were in the first test. The method of correlations as given elsewhere takes the changing conditions into account. Both methods have their uses.

In view of these facts, as illustrated by the records of Murne Cowan, what is the probable error within the limits of which we might expect the record of any one cow? The standard deviation of milk yield offers a means of determining this range. The standard deviation of the milk yields of 8-year-old cows is 2335 or the approximate probable error is 0.67449×2335 or 1575, or for any determination found in table 4 of Bulletin 311 of the Maine Station it is about an even chance that the actual milk yield of the cow will be within 1600 pounds either side of the figure shown. Thus for Murne Cowan's 6-year-old milk yield the probable 8-year production was $17{,}682 \pm 1575$ and the 11 year old milk yield predicted $17{,}695 \pm 1575$ as the probable 8-year-old production. In her phenomenal record this cow produced much over this mark. In fact, it may be shown that there is only one chance in over 25,000 that a cow would make such a record as she actually did.

The following references should be read:

REFERENCES

M. S., Chapter IV.

Pearl, Raymond, and Patterson, S. W. 1917. *The change of milk flow with age, as determined from the seven-day records of Jersey cattle,* Annual Report of the Maine Agricultural Experiment Station, Bulletin 262, pp. 145–152.

Pearl, Raymond, and Miner, John Rice. 1919. *The variation of Ayrshire cows in the quantity and fat content of their milk,* Jour. Agricultural Research, vol. XVII, pp. 285–322.

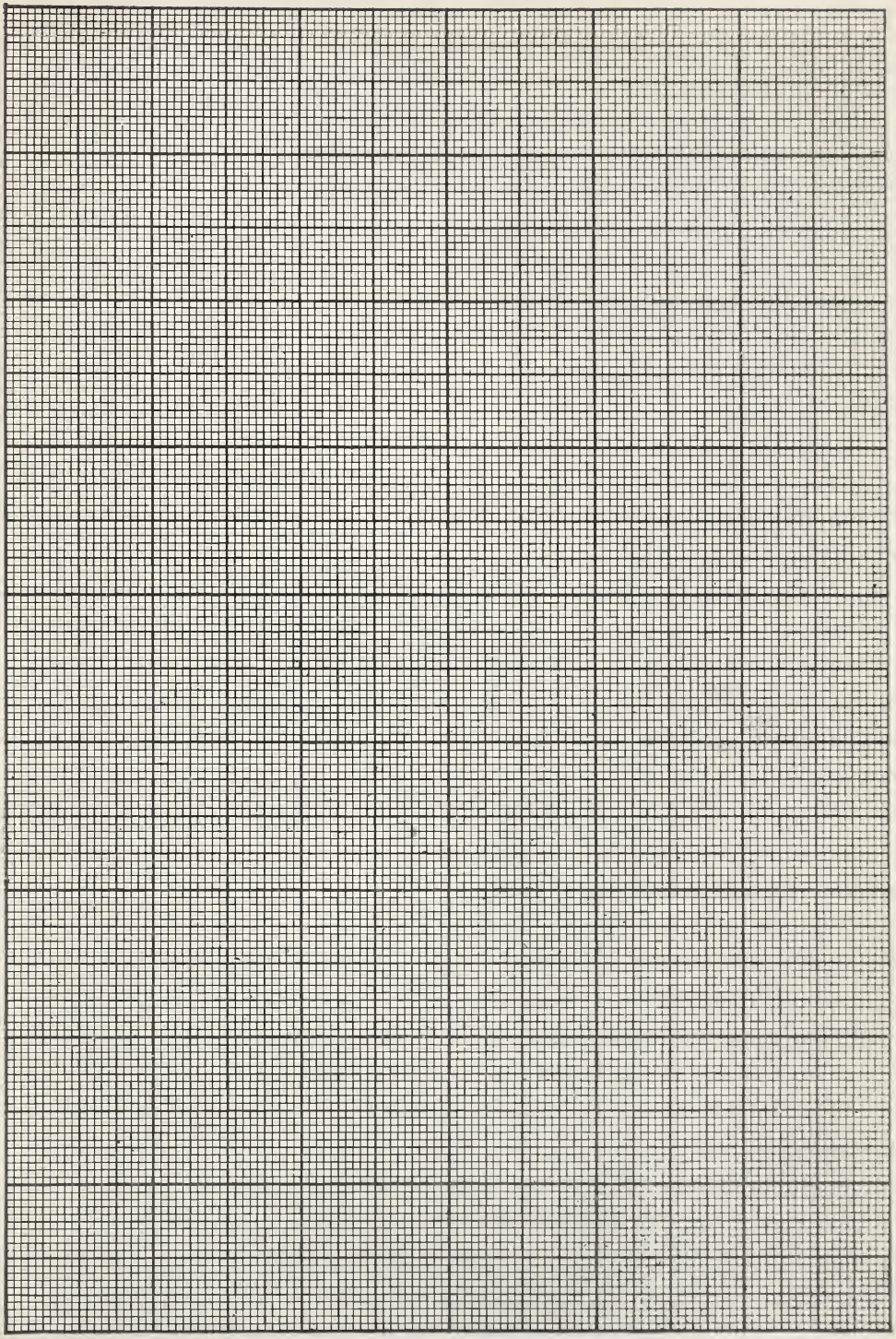
Pearl, Raymond, Gowen, John W., and Miner, John Rice. 1919. *Studies in milk secretion. VII. Transmitting qualities of Jersey sires for milk yield, butter-fat percentage,* Annual report of the Maine Agricultural Experiment Station for 1919, Bulletin 281, pp. 89–264.

Gowen, John W. 1920. *Studies in milk secretion VIII. On the influence of age on milk yield and butter-fat percentage, as determined from the 365-*

day records of Holstein-Friesian cattle, Annual Report of the Maine Agricultural Experiment Station, Bulletin 293, pp. 185–196.

Gowen, John W. 1923. *Studies in milk secretion XIV. The effect of age on the milk yields and butter-fat percentages of Guernsey Advanced Registry cattle,* Annual Report of the Maine Agricultural Experiment Station, Bulletin 311, pp. 9–20.

Brody, Samuel, Ragsdale, Arthur C., and Turner, Charles W. 1923. *The rate of growth of the dairy cow. IV. Growth and senescence as measured by the rise and fall of milk secretion with age,* Jour. Gen. Physiology, vol. VI, pp. 31–40.



Correction Factors for Milk Yield to a Standard Age

AGE	MEAN MILK YIELD	MULTIPLICATION FACTORS TO CORRECT TO 8 YEARS AS STANDARD AGE = 8-YEAR MILK YIELD / MILK YIELD OF AGE FOR WHICH CORRECTION IS TO BE MADE

Milk Yields of Guernsey Advanced Registry Cows Corrected to an 8-Year Basis

AGE IN YEARS	MILK YIELD AT GIVEN AGE																
	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000	16000	17000	18000	19000	
	MILK YIELD AT 8 YEARS																
1.75																	
2.00																	
2.50																	
3.00																	
3.50																	
4.00																	
4.50																	
5.00																	
5.50																	
6.00																	
6.50																	
7.00																	
7.50																	
8.00																	
8.50																	
9.00																	
9.50																	
10.00																	
10.50																	
11.00																	
11.50																	
12.00																	

CHAPTER XIII

Age of the Cow in Relation to the Butter-fat Percentage

This subject is much less complex than the same relations for milk yield. The relation is, in general, a linear one with a difference in the effect of age on the butter-fat percentage of the different breeds. The student will find it advantageous to calculate a table showing the raw data for the influence of age on the butter-fat percentage. These data may be found in the same references as those for the relation of age to milk yield.

The method of calculation necessary to determine this relation of age to butter-fat percentage may be illustrated by the table on milk yield on page 78 although the linear equation is not suited to describe the relation of milk yield to age. Summation X ($S(X)$) for each row of the table is obtained as previously described, $S(X)$ of the "Total" row is also calculated $(37 \times 1) + (389 \times 2) + (1125 \times 3) \ldots\ldots (1 \times 17) + (1 \times 21) = 61258$. The sum of the right hand column, $S(X)$ for each row is also equal to 61258 which checks the work thus far calculated. The figure 61258 is called $S(X)$ of the table. The next constant needed is $S(X^2)$. This is obtained by multiplying the totals of the lower row by the squares of the X row. Thus $(37 \times 1) + (389 \times 4) + (1125 \times 9) + (1800 \times 16) + (2055 \times 25) \ldots\ldots (1 \times 289) + (1 \times 441) = 406680$ = summation X^2, written $S(X^2)$. Similar values are now obtained for Y. Summation Y is equal to the totals of the right side of the table times the distance from the origin shown in column Y. Thus $S(Y)$ is equal to

$$(244 \times 1) + (2436 \times 2) + (1287 \times 3) + (1020 \times 4) \ldots\ldots (1 \times 31) + (1 \times 33) = 65190$$

Summation Y^2, $(S(Y^2))$, is equal to the total column times the squares of the distance from the origin or

$$(244 \times 1) + (2436 \times 4) + (1287 \times 9) + (1020 \times 16) \ldots\ldots (1 \times 961) + (1 \times 1089) = 607450$$

The last constant needed is summation (XY). This is determined by multiplying the summation of each row, $S(X)$ for each row, by the value of Y, thus:

$$(918 \times 1) + (11063 \times 2) + (6374 \times 3) + (5314 \times 4) \ldots . (5 \times 31) + (4 \times 33) = 418940$$

From these data it is now possible to obtain the correlation of age with milk yield. This coefficient is obtained as follows. Each of the constants are divided through by the total number of individuals in the table, 10644.

$$\frac{61258}{10644} = 5.755167 = \frac{S(X)}{n}$$

$$\frac{406680}{10644} = 38.207441 = \frac{S(X^2)}{n}$$

$$\frac{65190}{10644} = 6.124577 = \frac{S(Y)}{n}$$

$$\frac{607450}{10644} = 57.069710 = \frac{S(Y^2)}{n}$$

$$\frac{418940}{10644} = 39.359263 = \frac{S(XY)}{n}$$

To transfer our data to the true mean of the table, the following calculations are made.

$$38.207441 - (5.755167)^2 = 5.085494 = \sigma_x^2$$
$$57.069710 - (6.124577)^2 = 19.559267 = \sigma_y^2$$
$$39.359263 - (5.755167 \times 6.124577) = 4.111300$$

In symbols this relation is

$$\frac{S(X^2)}{n} - \left(\frac{S(X)}{n}\right)^2 = \sigma x^2$$

$$\frac{S(Y^2)}{n} - \left(\frac{S(Y)}{n}\right)^2 = \sigma y^2$$

$$\frac{S(XY)}{n} - \frac{S(X)}{n} \times \frac{S(Y)}{n} = \text{value of S(XY) around the true mean.}$$

The value of σ_x is equal to the square root of σ^2_x or $\sqrt{5.085494} = 2.255104$

The value of σ_y is equal to the square root of σ^2_y or $\sqrt{19.559267} = 4.422586$

The value of the correlation coefficient is equal to

$$\frac{4.111300}{2.255104 \times 4.422586} \text{ or } 0.412227 \text{ or in symbols } \frac{\frac{S(XY)}{n} - \frac{S(X)}{n} \times \frac{S(Y)}{n}}{\sigma x \times \sigma y} = r$$

The class interval, between 1 and 2 for instance of the X is equal to 1000 pounds of milk. The origin, O on the X scale, is equal to 3500 pounds of milk. In the same way the class interval for Y is equal to 0.5 of a year and the O origin is equal to 1.25. From these data the mean average milk yield and age at test is found to be:

$$5.755167 \times 1000 + 3500 = 9255 \text{ pounds of milk}$$
$$6.124577 \times 0.5 + 1.25 = 4.31 \text{ years of age}$$

The standard deviations for milk yield and age are equal to the σ times the class interval, or:

$$\sigma_X \times 1000 \text{ or } 2.55104 \times 1000 = 2255 \text{ pounds}$$
$$\sigma_Y \times 0.5 \text{ or } 4.422586 \times 0.5 = 2.21 \text{ years}$$

There are two possible linear equations for this correlation table, one to give the mean milk yields when the age is known and the other to give the mean ages when the milk yields are given. The equations are equal to:

$$\text{Mean milk yield} = 9255 - 0.412 \frac{2255}{2.21} 4.31 + 0.412 \frac{2255}{2.21} \text{ age},$$
$$\text{or mean milk yield} = 7443 + 420.4 \text{ age}.$$
$$\text{Mean age} = 4.31 - 0.412 \frac{2.21}{2255} 9255 + 0.412 \frac{2.21}{2255} \text{ milk yield},$$
$$\text{or mean age} = 0.61 + 0.0004 \text{ milk yield}.$$

In symbols, the equations are:

$$X = \text{mean}_X - r_{XY} \frac{\text{S.D.}_X}{\text{S.D.}_Y} \text{ mean}_Y + r_{XY} \frac{\text{S.D.}_X}{\text{S.D.}_Y} Y$$

$$Y = \text{mean}_Y - r_{XY} \frac{\text{S.D.}_Y}{\text{S.D.}_X} \text{ mean}_X + r_{XY} \frac{\text{S.D.}_Y}{\text{S.D.}_X} X$$

where S.D. is equal to the standard deviation.

As noted elsewhere the linear equations are not suited to the description of the relation between milk yield and age. The data are given merely for sake of illustration. It is realized that the description of the method is given in the most elementary terms. The student will find the reading of G. U. Yule, *An introduction to the theory of statistics*, J. B. Lippincott Company, Philadelphia, Chapters VI to X, of value.

In the student's paper on the relation between age and butter-fat percentage in cattle, it would be desirable to take one of the numerous tables for these relations to be found in the references and check over the calculations and form the curves. The student would do well to consider and discuss the question of whether or not the effect of age on butter-fat percentage is the same in all breeds of cattle.

REFERENCES

See those of Chapter XI.

CHAPTER XIV

Mode of Secretion of Milk in the Udder

This subject is still in its infancy so far as it concerns exact knowledge of how milk is actually secreted. The subject is, however, important enough for the student of heredity of milk yield to be reviewed by him. For the laboratory exercise, the review of the different original papers on this subject as cited in Chapter V of *M. S.* by different members of the class together with discussion of the conclusions drawn is suggested. It would also be desirable to have histological sections of udder tissue taken from an animal which had been completely milked out and from another before milking had commenced on demonstration for the students' microscopical study. Note should be taken of the size and character of the udder cells and the possibilities of distinguishing cell destruction versus any other theory, such as the secretion of the milk solids by the cells, to account for the formation of milk by the udder. The tissue for these sections might be obtained from slaughter houses where milking cows were killed, as for example where slightly diseased tubercular cattle were killed. Care should be taken to have good sections. These may possibly be obtained from the Histology section of the Biology department of the University.

CHAPTER XV

Permanence of Milk Yield and Butter-fat Percentage

It would be futile to study the inheritance of milk yield or to make Advanced Registry records if two major easily determined facts were not true: First, a record on one lactation should predict with reasonable certainty what the record in a subsequent lactation will be; second, as a corollary to this, a cow's milk record of one lactation should occupy the same relative position among the records of her herd companions that it does in another lactation. To test the accuracy with which these results follow from a study of cattle records the following tabulation of data is suggested (see pages 95–98).

Take the data of the college cows preferably using the lactation record of a definite length, for all cows having two or more lactations. Arrange the data so that all cows have records at two years, three years, and four years. Take the records of the cows at two years and arrange them in order of milk yield. Divide the group into as nearly four equal parts as possible, the first part to include the highest producing fourth of the cows, the next group the second highest producing fourth of the cows, the next group the third highest producing fourth of the cows, and the fourth group the lowest producing fourth of the cows. Calculate the average production of each group. Without changing the four groups calculate the average milk yield of each group for the same cows at three years of age and at four years of age. Plot the line showing the average production of the highest group, the second highest, the third highest and the lowest producing cows. What conclusions do you draw?

Do the same for the butter-fat percentage.

Write a short paper on this subject after reading the following references.

REFERENCES

M. S., Chapter VI.

Gavin, William. 1913. *Studies in milk records on the accuracy of estimating a cow's milking capacity by her first lactation yield,* Jour. Agric. Science, vol. 5, pp. 377–391.

Gowen, John W. 1920. *Studies in milk secretion V. On the variations and correlations of milk secretion with age in Jersey cattle,* Genetics, vol. 5, pp. 111–188.

Gowen, John W. 1920. *Studies in milk secretion VI. On the variation and correlations of butter-fat percentage with age in Jersey cattle,* Genetics, vol. 5, pp. 249–324.

Gowen, John W. 1923. *Studies in milk secretion XI. The relation between the butter-fat percentage of one lactation and the butter-fat percentage of a subsequent lactation in Guernsey Advanced Registry cattle,* Jour. Dairy Science, vol. VI, pp. 330–346.

Gowen, John W. 1923. *Studies in milk secretion X. The relation between the milk yield of one lactation with the milk yield of a subsequent lactation in Guernsey Advanced Registry cattle,* Jour. Dairy Science, vol. VI, pp. 102–121.

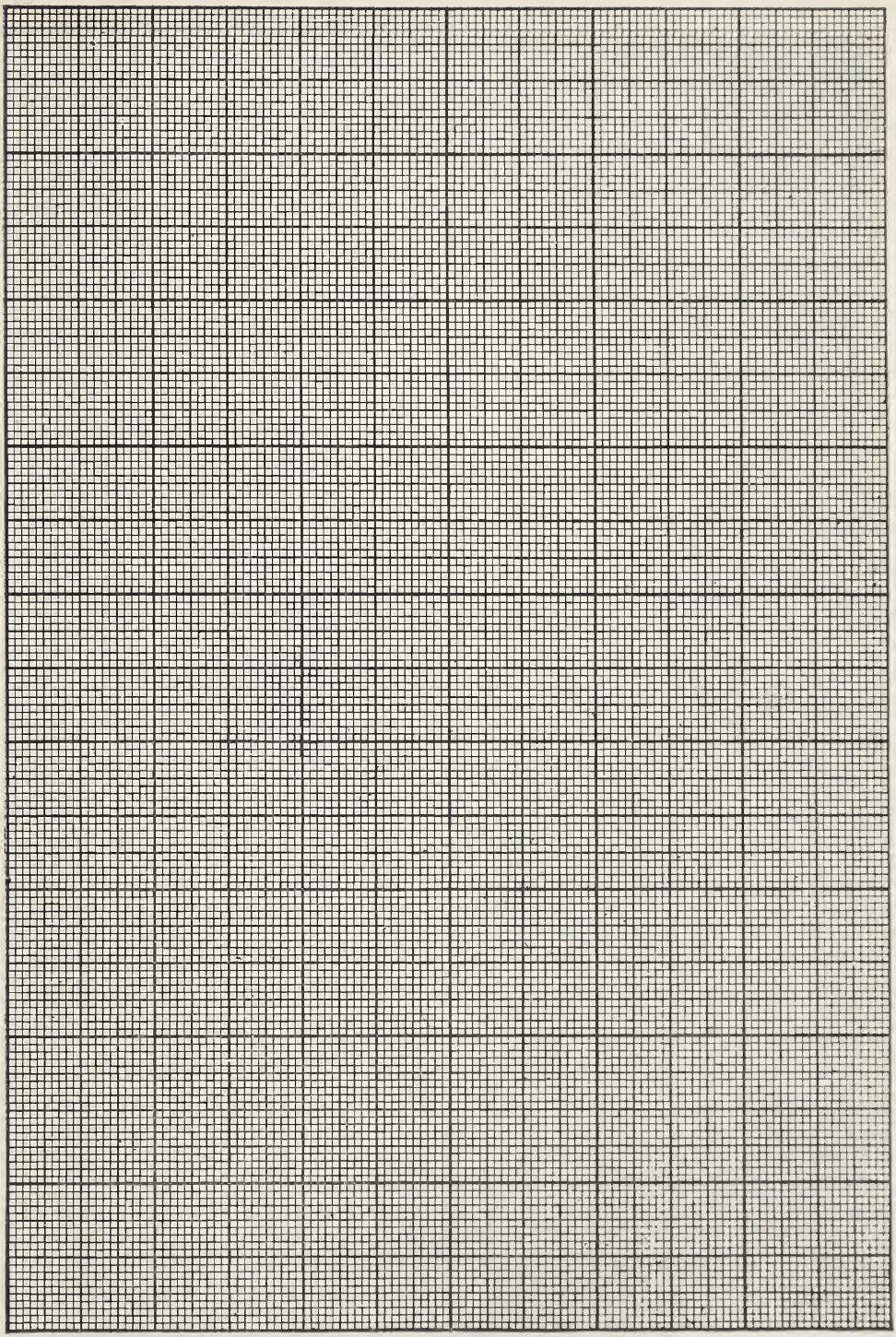
Gowen, Marie S., and Gowen, John W. 1922. *Studies in milk secretion XIII. The relation between milk yield and butter-fat percentage of the 7-day and 365-day tests of Holstein-Friesian Advanced Registry cattle,* Annual Report of the Maine Agricultural Experiment Station for 1922, Bul. 306, pp. 21–60.

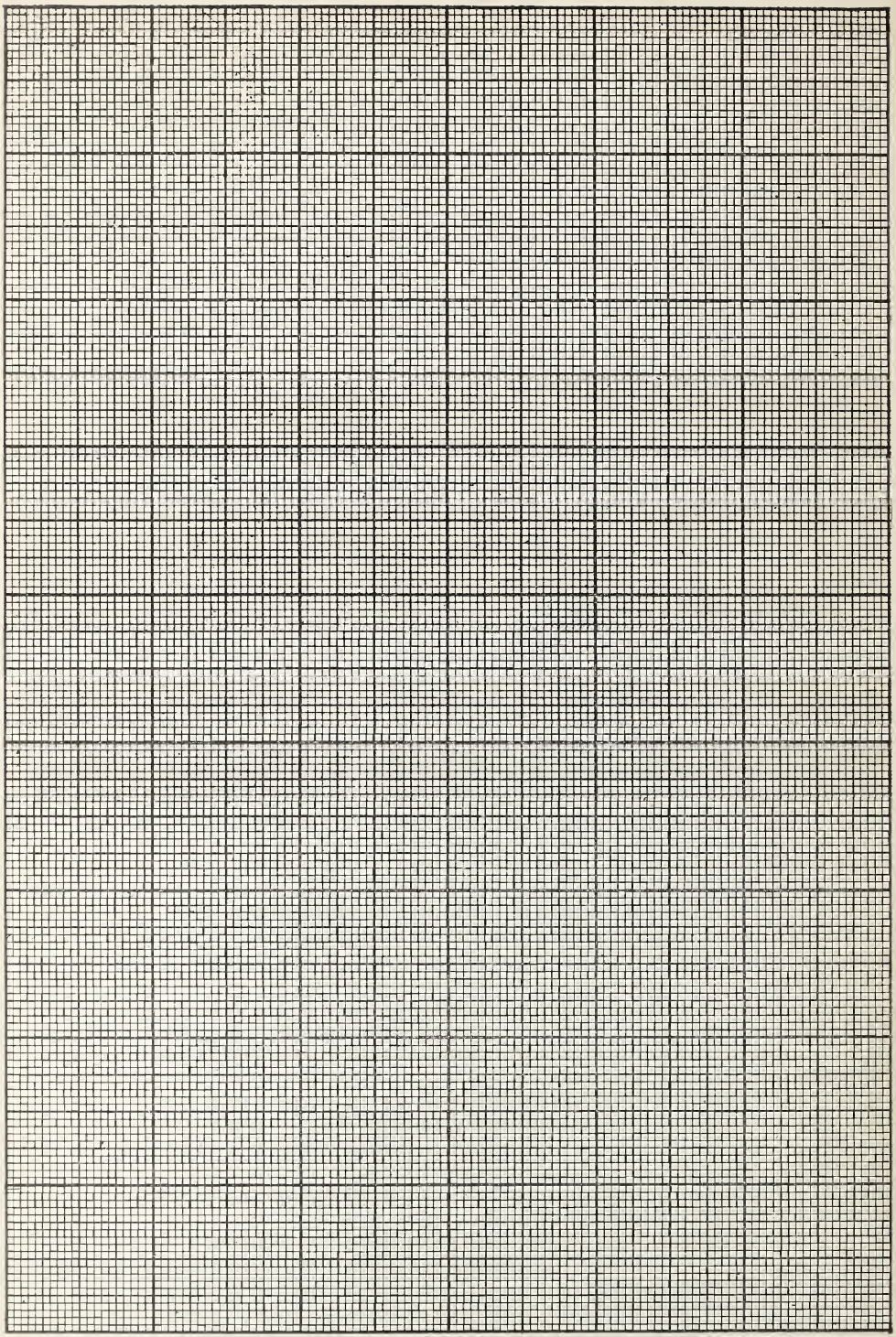
Permanence of Milk Yield

NAME OF COW (COWS ARRANGED ACCORDING TO 2-YEAR MILK YIELD)	2-YEAR MILK YIELD	3-YEAR MILK YIELD	4-YEAR MILK YIELD

Permanence of Butter-Fat Percentage

NAME OF COW (COWS ARRANGED IN ORDER OF 2-YEAR BUTTER-FAT PERCENTAGE)	2-YEAR BUTTER-FAT PERCENTAGE	3-YEAR BUTTER-FAT PERCENTAGE	4-YEAR BUTTER-FAT PERCENTAGE



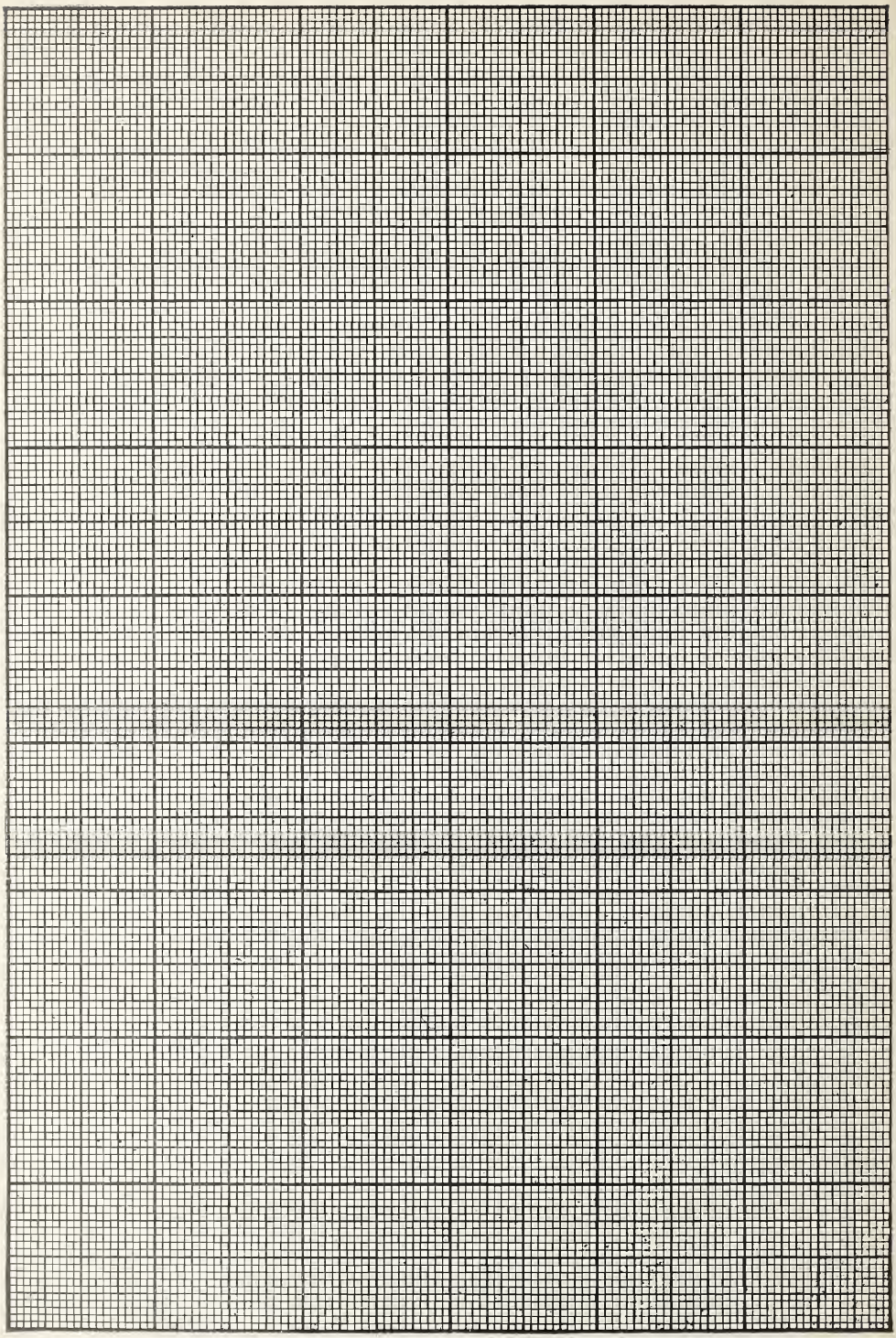


CHAPTER XVI

Inheritance of Milk Yield from Dam to Daughter

The student by this time is familiar with the herd book and Advanced Registries to such an extent that records may be easily found when wanted. The courageous student may be given the problem of finding his own original records for this study. He will need Advanced Registry record cows which have Advanced Registry record daughters. The milk yield records will have to be corrected for age by the methods previously given. With these records the direct comparison of the daughter's and dam's records may be made. This task is without much question too large for the limited time which may be devoted to this class. The next best thing is to take the records which have already been tabulated and have the student make the necessary calculations and deduce the results from them.

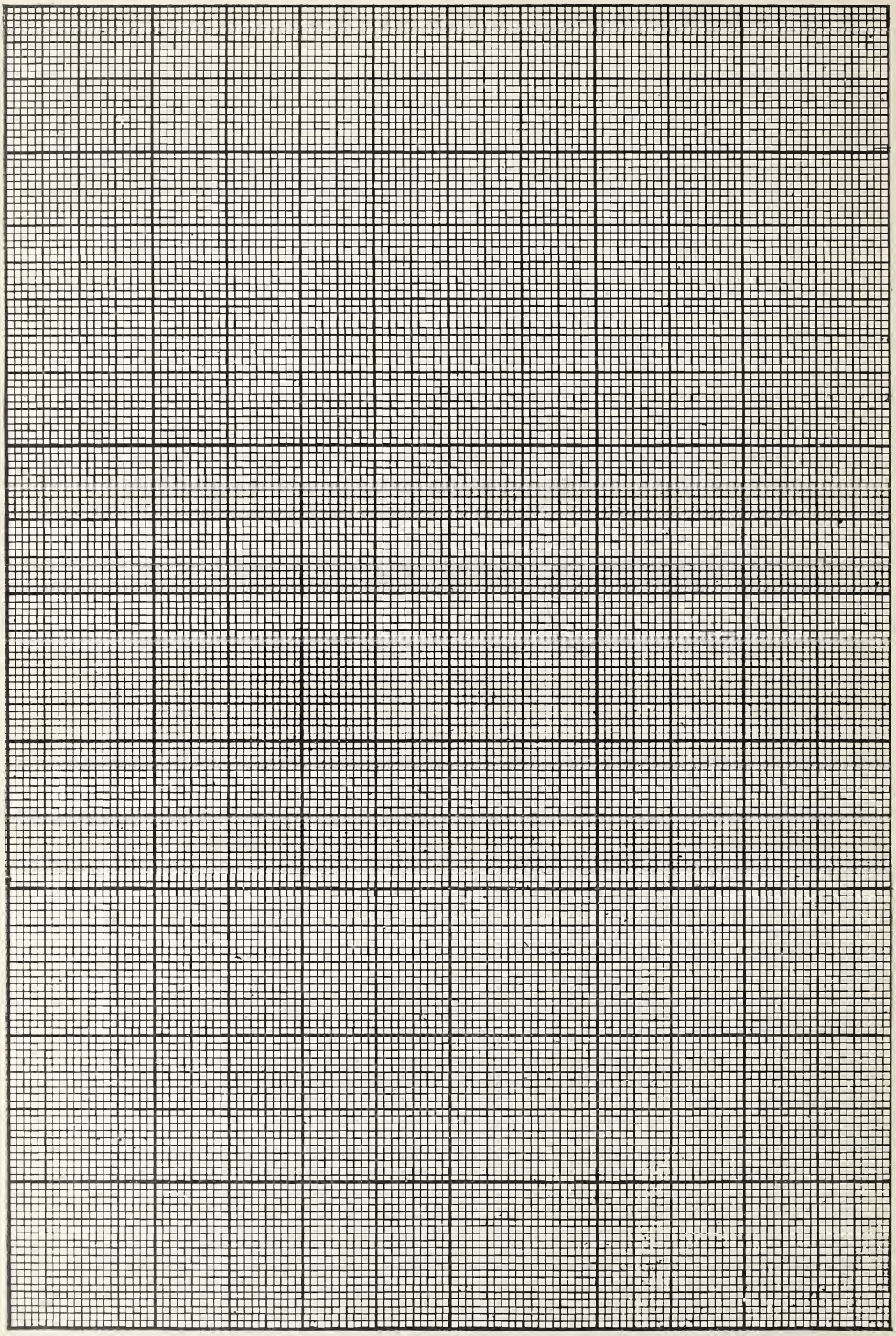
The writer consequently suggests that the class take table 80 of *M. S.* (or some such table where the work of tabulating has already been done) and calculate from it the mean milk yields of the daughters for each grade of milk yield of the dams in the manner given for exercise XII. Plot on cross section paper the average milk yields of the daughters for each grade of milk yield of the dam. What conclusions do you draw from this plot? After reading Chapters X, XI, XII, XIII, XIV, XV, and XVI in *M. S.* write a short paper on the inheritance of milk yield from the parents. Cross-section paper for this exercise is found on page 100.



CHAPTER XVII

Influence of the Grandparents on the Granddaughters' Milk Yield

The influence of the grandparents on the milk yields or butterfat percentages of the granddaughters may be tested in the same manner as in exercise XVI. Table 138 of *M. S.* would be a good one for the student to calculate and from which to plot the average milk production of the granddaughters for the granddam of a given grade of milk yield. The conclusions derived from the plot should be considered in conjunction with a study of the results given in Chapters XX, XXI, XXII, and XXIII of *M. S.* Cross-section paper for this exercise is found on page 102.



CHAPTER XVIII

The Inheritance of Milk and Butter-fat Percentage in Crosses of Animals Differing Widely in the Amounts of These Variables

Each student may review critically one of the following references and report on it. After the reports, have a general discussion of the subject by the members of the class with the object of coördinating the work of the different investigations and deriving conclusion of general application. The object of the reviews should be foremost in mind, namely, how the particular work furnishes evidence on the problem of the inheritance of milk yield and butter-fat percentage and the effects of dominance, heterosis, etc.

REFERENCES

Castle, W. E. 1919. *Inheritance of quantity and quality of milk production in dairy cattle,* Proc. National Academy of Sciences, vol. 5, pp. 428–434.

Lawritson, M. N., et al. 1919. *Purebred sires effect herd improvement,* Cir. 8, Nebraska Agric. Exper. Station, pp. 1–15.

Olson, T. M., and Biggar, G. C. 1922. *Influence of purebred dairy sires,* South Dakota Agric. Exper. Station Bul. 198, pp. 434–467.

Kildee, H. H., and McCandlish, A. C. 1916. *Influence of environment and breeding in increasing dairy production,* Iowa Agric. Exper. Station Bul. 165, pp. 383–402.

McCandlish, A. C., and Winters, L. M. 1920. *A study of bulls,* Jour. Dairy Science, vol. 3, pp. 529–539.

McCandlish, A. C. 1920. *Environment and breeding as factors influencing milk production,* Jour. Heredity, vol. XI, pp. 204–215.

McCandlish, A. C., et al. 1919. *Influence of environment and breeding in increasing dairy production—II,* Iowa Agric. Exper. Station Bul. 188, pp. 65–88.

Van Norman, H. E. 1907. *Influence of pure bred sires,* Report of Penn. State College, pp. 129–145.

Beam, A. L. 1915. *A study of the dairy herd records of Pennsylvania Experiment Station,* Report Penn. State College, pp. 349–386.

Wilson, J. H. 1917. *The effect of the sire on the herd,* Vermont Agric. Exper. Station Bul. 202, pp. 39–44.

Hayden, C. C. 1916. *The influence of sires on production,* Ohio Station, Monthly Bul., vol. 1, pp. 211–215.

Gaines, W. L. 1923. *The inheritance of fat content of milk in dairy cattle,* Proceedings Amer. Soc. Animal Production, pp. 29–32.

Ellinger, T. U. 1923. *The variation and inheritance of milk characters,* Proceedings Nat. Acad. Sciences, vol. 9, pp. 111–116.

Gowen, John W. 1920. *Inheritance in crosses of dairy and beef breeds of cattle II. On the transmission of milk yield to the first generation,* Jour. Heredity, vol. XI, pp. 300–314.

Gowen, John W. 1920. *Inheritance in crosses of dairy and beef breeds of cattle. III. Transmission of butter-fat percentage of the first generation,* Jour. Heredity, vol. XI, pp. 365–376.

CHAPTER XIX

The Chromosome Mechanism of Heredity in Relation to Dairy Cattle Inheritance

The cytology of the germ cells of cattle has been worked out by Wodsedalek and Masui. These papers may be read and discussed. Problems showing the probable distribution of the sex chromosomes and the proportion of chromosomes received by the offspring from certain of their grandparents may be worked. This information should then be considered from the view point of the inheritance of milk yield and butter-fat percentage. If it is possible to obtain slides of cattle test is or ovary from the Biology department of the University, the student will find it interesting to study them in the attempt to obtain the number of chromosomes and the manner in which they divide. Do not get discouraged if the first slides are not good for the material is difficult to fix properly; obtain fresh material and try fixing it again.

REFERENCES

Masui, Kiyoshi. 1919. *The spermatogenesis of domestic mammals II. The spermatogenesis of cattle (Bos taurus)*. Jour. Coll. Agr. Tokyo Imperial Univ. 3: 277–403.

Wodsedalek, J. E. 1920. *Studies on the cells of cattle with special reference to the spermatogenesis, oögonia, and sex-determination*, Biol. Bul., vol. 38, pp. 290–317.

See also *M. S.*, Chapter XXIX.

BIBLIOGRAPHY

The following references additional to those already given furnish a bibliography to most of the important papers on cattle breeding and inheritance. These papers deal with inheritance of such of the less important economic characters as coat color, twinning, cataract, etc. A brief review of these works is found in "A Résumé of Cattle Inheritance," *Bibliographia Genetica*, II: 287–337.

Allen, C. L. 1922. *The effect of the age of sire and dam on the quality of offspring in dairy cows*, Jour. Heredity, 13, pp. 167–176. See also Holstein Friesian World, 20 (1923), No. 17, pp. 817–819, 832.

Barrington, Amy, and Pearson, Karl. 1905. *On the inheritance of coat color in cattle. Part I. Shorthorn crosses and pure Shorthorns*, Biometrika, 4, pp. 427–464.

Bateson, W., and Saunders, E. 1902. *Experimental studies in the physiology of heredity*, Roy. Soc. (London), Rpts. Evol. Com., No. 1, pp. 3–160.

Boyd, M. M. 1908. *A short account of an experiment in crossing the American bison with domestic cattle*, American Breeders' Assoc. Proc., 4, pp. 324–331.

Boyd, M. M. 1914. *Crossing bison and cattle*, Jour. Heredity, V, pp. 189–197.

Brun, J. 1922. *Biometrical and hereditary studies of the escutcheons of cows*, Jahrb. Wiss. u. Prakt. Tierzucht, 15, pp. 72–124.

Campbell, M. H. 1924. *Inheritance of black and red coat colors in cattle*, Genetics, 9, pp. 419–441.

Castle, W. E., and Wachter, W. L. 1921. *Genetics of Hereford Cattle*, Jour. Heredity, 12, pp. 36–39.

Cole, L. J. 1916. *Twinning in cattle with special reference to the freemartin*, Science, N. S., 43, pp. 177–178.

Cole, L. J. 1919. *A defect of hair and teeth in cattle, probably hereditary*, Jour. Heredity, 10, pp. 303–306.

Cole, L. J. 1920. *Inheritance of milk and meat production in cattle*, Wis. Sta. Bull., 319, pp. 53, 54.

Van Damme, C. 1908. *Inheritance of coat color in the cattle of East Flanders*, Rev. Gen. Agron. n. Ser., 3, pp. 363–365.

Detlefsen, J. A. 1920. *A herd of albino cattle*, Jour. Heredity, 11, pp. 378–379.

Detlefsen, J. A., and Yapp, W. W. 1920. *The inheritance of congenital cataract in cattle*, Amer. Nat., 54: 277–280.

Duck, Russel W. 1923. *Colors of Shorthorn cattle*, Jour. Heredity 14: 65–75.

Dunn, L. C., Webb, H. F., and Schneider, M. 1923. *The inheritance of spotting in Holstein-Friesian cattle*, Jour. Heredity 14: 229–240.

Fogle, P. E. 1910. *Results from breeding grade Shorthorns to Hereford bull*, Amer. Breeders' Assoc. Proc., 6, pp. 373–375.

Fogle, P. E. 1912. *Transmission of color and color markings in Hereford-Shorthorn crosses*, Amer. Breeders' Jour., 3–4, pp. 201–204.

Funkquist, H. 1920. *The inheritance of muzzle color in the cattle breed of Stjernsund*, Hereditas, 1, pp. 343–363.

Funkquist, H., and Boman, Nils. 1923. *Vererbung "Weisser Abzeichem" bei Rindern*, Hereditas 4: 65–80.

Goodnight, C. 1914. *My experience with bison hybrids*, Jour. Heredity, 5, pp. 197–199.

Gowen, John W. 1918. *Studies in inheritance of certain characters of crosses between dairy and beef breeds of cattle*, Jour. Agr. Research, XV, pp. 1–57.

Gowen, John W. 1918. *Inheritance studies of certain color and horn characters in first generation crosses of dairy and beef breeds*, Maine Agr. Expt. Station Annual Report for 1918. Bulletin 272, pp. 129–148.

Gowen, John W. 1918. *Report of progress on animal husbandry investigations in 1917*. Annual Report of the Maine Agr. Expt. Station for 1918, Bulletin 274, pp. 205–228.

Gowen, John W. 1919. *Studies on milk secretion. IV. On the variation and mode of secretion of milk solids*, Jour. Agr. Research XVI, pp. 79–102.

Gowen, John W. 1919. *Report of progress on animal husbandry investigations in 1919*. Annual Report of the Maine Agr. Expt. Station for 1919, Bulletin 283, pp. 249–284.

Gowen, John W. 1920. *Studies in milk secretion. VII. On the variations and correlations of butter-fat percentage with age in Jersey cattle*, Genetics 5: 249–324.

Gowen, John W. 1921. *Report of progress on animal husbandry investigations in 1920*. Annual Report of the Maine Agr. Expt. Station for 1921, Bulletin 299, pp. 85–120.

Gowen, John W. 1922. *Identical twins in cattle?* Biol. Bull. XLI, pp. 1–6.

Gowen, John W. 1923. *Studies on conformation in relation to milk producing capacity in cattle. III. Conformation and milk yield in the light of the personal equation of the dairy cattle judge*, Annual Report Maine Agr. Expt. Station for 1923, Bulletin 314, pp. 69–96.

Gowen, John W. 1924. *Intrauterine development of the bovine fetus in relation to milk yield in Guernsey cattle*, Journal Dairy Science, 7: 311–317.

Gowen, John W. 1924. *Inheritance of milk production*, Sci. Agr., IV, pp. 365–380.

Gowen, John W. 1924. *The application of the science of genetics to the farmers' problems*, Sci. Agr., V., pp. 1–12.

Gowen, John W., and Covell, Mildred R. 1921. *Studies in milk secretion. IX. On the performance of the progeny of Holstein-Friesian*

sires, Annual Report of the Maine Agr. Expt. Station for 1921, Bull. 300, pp. 121–252.

Gowen, John W., and Covell, Mildred R. 1921. *Studies in milk secretion. XII. Transmitting qualities of Holstein-Friesian sires for milk yield, butter-fat percentage, and butter-fat.* Annual Report of the Maine Agr. Expt. Station for 1921, Bull. 301, 253–308.

Hammond, J. 1920. *On the relative growth and development of various breeds and crosses of cattle*, Jour. Agric. Sci., 10: 233–289.

Hayden, C. C. 1922. *A case of twinning in dairy cattle*, Ohio Sta. Mo. Bul. 7, No. 3–4, pp. 54–57.

Hayden, C. C. 1922. *A case of twinning in dairy cattle*, Jour. Heredity, 13: 22–24.

Hays, F. A. 1919. *Inbreeding animals*, Delaware Agric. Expt. Station Bull., 123, pp. 1–49.

Hesse, G. 1913. *Inbreeding and heredity studies with cattle of the West Prussian Herd book*, Arb. Deut. Gesell. Züchtungsk., No. 18, pp. VI + 215.

Hills, F. B., and Boland, E. N. 1913. *Segregation of fat factors in milk production*, Proc. Iowa Acad. Sci., 20, pp. 195–198.

Hooper, J. J. 1919. *Inheritance of Jersey colors*, Jour. Dairy Sci., 2: 290–292.

Hooper, J. J. 1920. *A study of inheritance of coat colors in Jersey cattle*, Science 52: 43. July 9.

Hooper, J. J. 1921. *Color of crossbred calves*, Jour. Heredity, 12: p. 480.

Hooper, J. J. 1921. *Studies of dairy cattle*, Kentucky Sta. Bul., 234, pp. 91–161.

Jones, Sarah V. H., and Rouse, James E. 1920. *The relation of age of dam to observed fecundity in domesticated animals. I. Multiple birth in cattle and sheep*, Jour. Dairy Sci., 3: 260–290.

Kirchner, W. 1901. *Influence of heredity upon the percentage of butter-fat in milk*, Mitt. Landw. Inst. Univ. Leipzig, No. 2, pp. 129–139.

Kuiper, K. 1921. *Color inheritance in cattle*, Jour. Heredity, 12: 102–109.

Laughlin, H. H. 1911–1912. *The inheritance of color in Shorthorn cattle*, Amer. Nat., 45, pp. 705–742, 46, pp. 5–28.

Lillie, Frank R. 1917–1918. *The freemartin, a study of the action of sex hormones in the foetal life of cattle*, Jour. Exp. Zool., 23, 371–452, Abst. in Jour. Roy. Microsc. Soc., 1918, 37–38.

Lillie, Frank R. 1923. *Supplementary notes on twins in cattle*, Biol. Bull., 44, pp. 47–78.

Lloyd-Jones, O., and Evvard J. 1916. *Inheritance of color and horns in blue-gray cattle*, Iowa Sta. Research Bul., 30, pp. 67a–106a.

Lush, J. L. 1922. *An hereditary notch in the ears of Jersey cattle*, Jour. Heredity, 13, pp. 8–13.

Marshall, F. R. 1914. *Holstein milk yield*, Jour. Heredity, 4, pp. 437–439.

Nabours, R. K. 1912. *Evidence of alternative inheritance in the F_2 generation from crosses of Bos indicus on B. taurus*, American Nat., 46, pp. 428–436.

Parlour, W. 1913. *Jersey-Angus cattle*, Live Stock Jour. (London), 77, No. 2025, p. 85.

Pearl, Raymond. 1912. *A case of triplet calves, with some general considerations regarding multiple gestation in normally uniparous animals*, Maine Agr. Expt. Station Annual Report for 1912, Bulletin 204, pp. 259–282.

Pearl, Raymond. 1913. *A contribution towards an analysis of the problem of inbreeding*, American Naturalist, XLVII, pp. 577–614.

Pearl, Raymond. 1913. *Variation in the tongue color of Jersey cattle.* Proceedings of the Society for the Promotion of Agricultural Science, pp. 49–57.

Pearl, Raymond. 1913. *Constants for normal variation in the fat content of mixed milk*, Maine Agr. Expt. Station Annual Report for 1913, pp. 299–305.

Pearl, Raymond. 1914. *On the results of inbreeding a mendelian population: a correction and extension of previous conclusions*, American Naturalist, XLVIII, pp. 57–62.

Pearl, Raymond. 1914. *Studies on inbreeding. IV. On a general formula for the constitution of nth generation of a mendelian population in which all matings are of brother × sister*, American Naturalist, XLVIII, pp. 491–494.

Pearl, Raymond. 1914. *Studies on inbreeding. V. Inbreeding and relationship coefficients*, American Naturalist, XLVIII, pp. 513–523.

Pearl, Raymond. 1914. *On the law relating milk flow to age in dairy cattle*, Proceedings of the Society for Experimental Biology and Medicine, XII, pp. 18–19.

Pearl, Raymond. 1915. *Studies on inbreeding. VI. Some further considerations regarding cousin and related kinds of mating*, American Naturalist, XLIX, pp. 570–575.

Pearl, Raymond. 1916. *Reports of progress on animal husbandry investigations in 1915*, Me. Agr. Expt. Sta. Circ., 519, pp. 1–27.

Pearl, Raymond. 1917. *Report of progress on animal husbandry investigations in 1916.* Annual Report of Maine Agr. Expt. Station for 1917, Bulletin 261, pp. 121–144.

Pearl, Raymond. 1918. *Studies on inbreeding. VIII. A single numerical measure of the total amount of inbreeding*, Amer. Nat., LI, pp. 636–639.

Pearl, Raymond, and Miner, John Rice. 1913. *Tables for calculating coefficients of inbreeding*, Maine Agr. Expt. Station, Annual Report for 1913, pp. 191–202.

Pearl, Raymond, and Patterson, S. W. 1917. *The change of milk flow with age, as determined from the seven day records of Jersey cattle*, Annual Report, Maine Agr. Expt. Station, Bulletin 262, pp. 145–152.

Pearson, K. 1910. *Note on the separate inheritance of quantity and quality in cow's milk*, Biometrika, 7, pp. 548–550.

Peters, J. 1913. *Inheritance of milk production and its significance to cow-testing association*, Deut Landw. Tierzucht, 17, Nos. 11, pp. 121–125; 12, pp. 133–135; 13, pp. 145–149.

PITT, FRANCES. 1920. *Notes on the inheritance of colour and markings in pedigree Hereford cattle*, Jour. Genetics, 9: 281–302.

PUTNEY, F. S. 1910. *The theory of dynamic heredity in the light of data gathered from the dairy herd of the Missouri Agricultural College*, Amer. Breeders Assoc. Proc., 6, pp. 310–317.

RICHARDSON. 1914. *Heredity of color in cattle*, Deut. Landw. Tierzucht, 18, No. 6, pp. 61–65.

RIETZ, H. L. 1909. *On inheritance in the production of butter-fat*, Biometrika, 7, pp. 106–126.

ROBERTS, E. 1921. *Polydactylism in cattle*, Jour. Heredity, 12, pp. 84–86.

SMITH, A. D. B. 1925. *Color inheritance in Shorthorn cattle*, Jour. Heredity, 16, pp. 73–84.

SPILLMAN, W. J. 1905. *Mendel's law in relation to animal breeding*, American Breeders Assoc. Proc., 1, pp. 171–177.

SPILLMAN, W. J. 1913. *Inheritance of the poll character in cattle*, Annual Report Amer. Polled Jersey Cattle Co., pp. 8.

STEVENS, H. D. E. 1913. *Jersey-Angus cattle*, Live Stock Jour. (London) 77, No. 2025, p. 132.

STORER, J. *The wild white cattle of Great Britain*, Lond., pp. 234.

TANDLER, JULIUS, AND KELLER, KARL. *Über das Verhalten des Chorions bei verschiedengeschlechtlicher Zwillingsgravidität des Rindes und über die Morphologie des Genitales der Weiblichen Tiere welche einer solchen Graviditätentstammen*, Deutsche Tierärzt. Wochenschrift, Jahrg. '19.

TEMPLETON, G. S. 1923. *Unusual color inheritance*, Jour. Heredity, 14: 39–40.

UHLMAN, E. 1914. *The inheritance of twin calving in cattle*, Deut. Landw. Tierzucht, 18, No. 14, pp. 163–164.

WATSON, J. A. S. 1919. *Problems of animal breeding*, Scottish Jour. Agric., 2: 449–456.

WATSON, J. A. S. 1921. *A mendelian experiment with Aberdeen-Angus and West Highland cattle*, Jour. Genetics, 11, pp. 59–67.

WENTWORTH, E. N. 1912. *Concerning "blue-gray" cattle*, Amer. Breeders Mag. 5, No. 2, pp. 9, 10.

WENTWORTH, E. N. 1913. *Color in Shorthorn Cattle*, Amer. Breeders Mag. 4, pp. No. 202–208.

WENTWORTH, E. N. 1916. *A sex-limited color in Ayrshire cattle*, U. S. Dept. Agr. Jour. Agr. Research, 7, pp. 141–147.

WILSON, J. 1908. *Mendelian characters among Shorthorn cattle*, Sci. Proc. Roy. Dublin Soc., n. ser., 11, No. 28, pp. 317–324.

WILSON, J. 1909. *The colors of Highland cattle*, Sci. Proc. Roy. Dublin Soc., n. ser., 12, pp. 66–76.

WILSON, J. 1910. *The separate inheritance of quality and quantity in cows' milk*, Sci. Proc. Roy. Dublin Soc., n. ser., 12, pp. 470–479.

WILSON, J. 1911. *The inheritance of milk yield in cattle*, Sci. Proc. Roy. Dublin Soc., n. ser., 13, pp. 89–113.

WODSEDALEK, J. E. 1918. *Cytological studies of the reproductive cells of cattle*, Idaho Sta. Rpt., 1918, p. 34.

WOODWARD, T. E. 1916. *Is the ability to produce milk fat transmitted by the dam or by the sire?*, Hoard's Dairyman, 51, p. 146.

WRIEDT, C. 1919. *The brindle color in cattle in relation to red*, Jour. Genetics, 9, p. 83.

WRIEDT, C. 1924. *Formalism in breeding of live-stock and modern research on heredity.* Rev. Sci. and Pract. Agr. N. S. 2, pp. 325–331.

WRIEDT, C. 1925. *Colorsided cattle.* Jour. Heredity, 16, pp. 51–56.

WRIGHT, S. 1917. *Color inheritance in mammals. VI. Cattle*, Jour. Heredity, 8, pp. 521–527.

YAMANE, J. 1915. *On the inheritance of an aural abnormality in the Ayrshire cattle*, Jour. Col. Agr. Tohoku Imp. Univ., 6, No. 7, pp. 166–170.

INDEX

Sans Tache

Sans Tache

IN THE "elder days of art" each artist or craftsman enjoyed the privilege of independent creation. He carried through a process of manufacture from beginning to end. The scribe of the days before the printing press was such a craftsman. So was the printer in the days before the machine process. He stood or fell, as a craftsman, by the merit or demerit of his finished product.

Modern machine production has added much to the worker's productivity and to his material welfare; but it has deprived him of the old creative distinctiveness. His work is merged in the work of the team, and lost sight of as something representing him and his personality.

Many hands and minds contribute to the manufacture of a book, in this day of specialization. There are seven distinct major processes in the making of a book: The type must first be set; by the monotype method, there are two processes, the "keyboarding" of the MS and the casting of the type from the perforated paper rolls thus produced. Formulas and other intricate work must be hand-set; then the whole brought together ("composed") in its true order, made into pages and forms. The results must be checked by proof reading at each stage. Then comes the "make-ready" and press-run and finally the binding into volumes.

All of these processes, except that of binding into cloth or leather covers, are carried on under our roof.

The motto of The Williams & Wilkins Company is *Sans Tache*. Our ideal is to publish books *"without blemish"*—worthy books, worthily printed, with worthy typography—books to which we shall be proud to attach our imprint, made by craftsmen who are willing to accept open responsibility for their work, and who are entitled to credit for creditable performance.

The printing craftsman of today is quite as much a craftsman as his predecessor. There is quite as much discrimination between poor work and good. We are of the opinion that the individuality of the worker should not be wholly lost. The members of our staff who have contributed their skill of hand and brain to this volume are:

Composing Room: Andrew Rassa, William Sanders, James Jackson, George Moss, William Fite, Ernest Salgado, Steve Simmons, Austin Uhland, William Koch, Herbert Leitch, Nathan Miller, Harry Harmeyer, Edgar Simmons, Roland Stultz, Henry Shea, Edward Rice.

Keyboard: Minnie Foard, Katharine Kocent, Harry Susemihl, Anna Kelly, Eleanor Luecke.

Proof Room: Sarah Katzin, Alice Reuter, Mary Reed, Ruth Treischman, Ethel Strasinger, Lucille Bull, Angeline Eifert, Audrey Tanner, Edna Clark, Lewis Forney, Dorothy Strasinger, Lillian Gilland, Arthur Baker, Geraldine Brown.

Casters: Kenneth Brown, Ernest Wann, Mahlon Robinson, Charles Aher, George Smith, Frank Malanosky, Martin Griffen, Henry Lee, Frederick Wall.

Press: Leonard Dumler, Jr., Henry Eckert, Fred Lucker, August Hildebrand.

Folder: Laurence Krug.

Cutter: John Murphy.